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THE FIRST BUILDING COMPLETED. SERVICE BUILDING FOR THE PANAMA-PACIFIC EXPOSITION, NOW BEING OCCUPIED BY THE ENGINEERING AND ARCHITECTURAL DEPARTMENTS.

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EDITORIAL

HETCH-HETCHY sounds like an overdose of snuff. It is said to be an Indian word meaning 'great wind.' An interesting example of cause and effect is shown in the quantity of cough syrup, quinine, and the like itemized in the expense accounts of the engineers who have been gathering water supply data in the valley. If the Spring Valley Water Company does not come to terms with San Francisco, everybody will make a noise like Hetch-Hetchy.

WHY don't they build dams on the Mississippi? The answer to this antiquated conundrum will have to be revised, as a dam nearly a mile long is nearing completion between Keokuk, Iowa, and Hamilton, Illinois, and forms a part of what is said to be the largest hydro-electric power installation in the world. Three hundred thousand horsepower will be generated by thirty 10,000 horse-power turbine generating sets weighing over 400 tons each. Mr. Hugh L. Cooper is chief engineer in charge of the work, his experience in similar work at Niagara standing him in good stead in working out the details of this great project.

STOCKTON forms the battle ground on which a most interesting phase in the operation of the California Public Utilities Act is being fought. The Western States Gas & Electric Co., one of the utilities controlled by H. M. Byllesby & Company, has served the city of Stockton with gas and electricity for many years. The Oro Electric Company, which is developing its power project and extending its distributing lines wherever it can find an outlet, has applied to the State Railroad Commission for permission to serve Stockton also. The granting of this application is being opposed by the Western States Company on the ground that the existing service is adequate and the prices reasonable, and that for this reason, under the law, this company is entitled to be protected from the threatened competition. At the first hearing before the board, Mr. Eshleman, the president, stated that where a territory was completely served by a public utility company at a reasonable rate of compensation, competition would not be allowed. The issue before the board, therefore, narrows down to a single point: whether or not the service of the Western States Company is adequate and the charges fair. Apparently the burden of proof lies with the applicant. The public utilities act is designed to protect both producer and consumer, and without expressing an opinion as to the merits of the case, we believe that unless the evidence shows a clear case of overcharge or inadequate service, the company in possession of the field should receive first consideration.

HOW engineers may increase their earnings is a problem. The universities and colleges are turning out engineering graduates at the rate of about 5000 annually. The effect of the oversupply is so keenly felt in the vicinity of New York that, according to one of our contemporaries, steps have been taken by a number of young civil engineers to form a union. A

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charter is said to have been granted them by the American Federation of Labor and a similar union is in process of formation in Chicago. The whole principle of restricted competition is to be carried out, all plans and specifications are to bear the union label, and with the coöperation of their brother trade unionists among the mechanics and laborers, these young men hope to better their financial condition. We have the greatest sympathy with any movement that may improve the financial condition of the engineer, but it is to be regretted that any body of engineering graduates, however young and inexperienced, can have so little conception of the dignity of their profession. An engineering graduate fresh from college must start at the bottom of the list. His progress from that time on depends upon his powers of application and ability. The engineer who may be said to have 'arrived' at 30 is an exception, but we are of the opinion that the man who is backed by perseverance and the love of his profession will be earning an amount far in excess of the pay of the average mechanic by the time he has reached that age. There is no royal road to success. Only through steady, persistent, and consistent work can one hope to win for oneself that which the world offers to the man who has 'made good.'

Reclamation Service Difficulties

Additional evidence that public service is a thankless task is shown in the attack on the Reclamation Service made by the House Committee on Interior Department Expenditures. Mr. Samuel Adams, Assistant Secretary of the Interior, Mr. F. H. Newell, Director of the Service, and Mr. L. C. Hill, supervising engineer, are charged with having discriminated against the farmers in favor of the corporations operating the canals, while the bondholders thereof are alleged to have "alone received attention from them in the Salt River project." It is further alleged that as the reclamation act provides that only the estimated cost of construction may be received by the Government, the estimated cost having been $3,850,000, and expenditures to date $10,547,396, the loss to the Government is apparently largely in excess of $6,000,000. Mr. Newell characterizes the statement that the Government will lose $6,000,000 on the Salt River project as absurd and states that it will collect every dollar invested there if the present law is not changed. He states further that an investigation by competent and honest men will be welcome. The Reclamation Service has already been investigated more than once and in each case came out with flying colors. We fear that the Committee has been imposed upon by some of those whose private plans have been upset by the work of the Service. In building and operating the extensive works that have fallen to the lot of the Reclamation Service it is inevitable that minor mistakes be made, and there has been abundant occasion for rousing antagonism. There are peculiar difficulties in the way of a Government bureau such as this, since it is practically impossible that it should select the persons who are to settle on the reclaimed land, and the words "government land" inevitably attract to the lands many who are totally unfit for farming. If the matter be arranged so that there is no middleman's profit, a small but active group is aroused to fighting, for it is well known that in land settlement the middleman absorbs a large part of the increment of value. If any such syndicate be incidentally helped through inclusion under a proj-

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ect of lands in private ownership, when the works were planned, there is a still louder protest from those who fail to participate in the profit. In the matter of power, the conditions are similar. The Government finds, as do many private power companies, that the most economical and efficient distribution can only be accomplished through cooperation with existing concerns. It is usually better to sell the power at the generating station in large amounts to companies already in the business of distributing power than to have too many irons in the fire at once. Powermen, and large consumers, recognize thoroughly that because of the standby charge, it is unfair to sell on the same terms to large steady users and to small occasional consumers. This, to the people drawn to settle on Reclamation projects, many of them facing radically new conditions, is rank heresy. As is true of too many who ought to be better informed, the economic function of the middleman is not recognized. The Reclamation Service is a clean branch of the Government and one that has been conducted with conspicuous ability under especially trying circumstances. We bespeak for it sympathy and suspended judgment until both sides of the case shall have been fully heard.

The Status of the Diesel Engine

Power producers and consumers alike will be interested in the article we print this month by Mr. Herbert Haas on the stationary Diesel engine. This interesting type of prime mover, while new, is not of such recent origin as the present interest in it would indicate. Mr. Haas shows that Mr. Diesel gave before the Verein Deutscher Ingenieure in June 1897 what may be considered the first exhaustive discussion of the practical operation of his now famous cycle. The time that has elapsed between the first conception of the idea and the recognition of its importance by the world at large indicates the vast amount of labor involved in carrying an idea through the many stages between the propounding of a new theory and its ultimate reduction to a successful mechanism. While nothing can detract from the honor due and accorded Mr. Diesel by the world of science, yet the work done by manufacturers is also entitled to recognition. The countless details that make for success or failure were, for the most part, worked out by manufacturers who were confident of ultimate success. They spent their money freely in the accumulation of experience and a scrap pile until the Diesel engine attained its present development. When a new idea attracts attention, people are apt to apply it indiscriminately as a panacea for all ills, which frequently results in losing as many patients as are saved. Mr. H. J. Freyn, chairman of the Gas Power Section of the American Society of Mechanical Engineers, in discussing the recent development of gas power in Europe, expresses the opinion that the warning against over-enthusiasm sounded over a year ago was fully justified. Mr. Freyn's opinions are the result of observations during an extended trip through Europe, and being based upon a careful investigation of many operating plants, are entitled to careful consideration. The item of first importance in considering the installation of any engine, is the operating cost per horse-power, and by this is not meant merely fuel cost, nor the cost based upon the builders' test during a trial run over a limited period. No selection of power-generating apparatus should be made without a careful study of load and power factors. The

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cost of generating power under such conditions as exist can be readily calculated and tabulated for all types of prime-mover that may be applicable to the project under consideration. Fuel consumption is only one of many items entering into cost of power generation. Interest on investment, depreciation, and other fixed charges, as well as maintenance, lubrication, labor, and load-factor influence choice. While Mr. Freyn states that the achievements of the large Diesel engines above 1000 horse-power do not altogether coincide with the optimistic reports appearing in the technical press of a year or two ago, the smaller sizes of from 40 to 50 horse-power in single units, and up to about 600 horse-power in 4-cylinder units, have reached a high degree of perfection. The reason for this is not difficult to understand. Outside of the simplicity of the engine itself, it is always ready for instant service. It has no stand-by losses, requires practically no attendance, and its cost, compared to a steam or gas plant, is reasonable. Another great advantage is that the actual fuel consumption taken over long periods of operation does not materially exceed the guaranteed figures. Mr. Freyn cites an instance where, during a period of one year, the fuel consumption for a number of Diesel-engine plants was only 14 per cent over the manufacturer's guarantee, whereas it averaged 120 per cent more in high-class steam-plants over the same period. In this comparison, 27 installations containing units of from 50 to 80 horse-power were investigated, of which 15 were Diesel-engine plants and 12 were steam plants. The question as to what extent the Diesel engines will develop in the United States is debatable. That it will find an equal development in all sections is open to doubt, as the fuel supply and cost will settle this question in each case individually. When the load factor is comparatively high, and oil is available at a price that will compare favorably with that of coal, the Diesel engine will undoubtedly find an extensive application. In the case of some of the Eastern states, which produce large quantities of both oil and coal at low prices, the steam turbine and reciprocating engines will probably hold their own even in the smaller sizes. In the Western and Pacific Coast states, however, the situation is completely changed. No steam coal of any account is produced, and oil is used almost universally for steam-generating purposes. California crude oil of 14° Baumé gravity is sold at about 35 cents per barrel of 42 gallons, 330 pounds, at the well, or about 75 to 85 cents at the Pacific seaboard. These prices are very low, however, and do not represent a fair compensation to the producers. Any future changes will undoubtedly be in the line of advances, as the consumption shows signs of overtaking the production, in spite of the large increase in 1912 over previous years. California and the other Pacific Coast states should therefore offer an exceptionally good field for the Diesel engine in units up to 1000 horse-power, as a fuel consumption of under 0.5 pound per brake horse-power hour certainly offers a phenomenally cheap fuel-cost in comparison with other types of prime-mover in the smaller sizes. Of the larger sizes, however, it is a question whether the supremacy of the steam turbine can be successfully assailed. Engineers throughout the West are waiting with great interest for the first installation of a Diesel engine that will be operated with California crude oil. The proof of the pudding lies in the eating. We hope that our hunger soon will be appeased.

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REVIEW OF THE MONTH

WAR is the keynote for the month. Hostilities have been resumed in the Balkans and peace seems as far away as ever. Even in staid old London, the activities of the suffragettes savor more of war than a mere local disturbance. Word has come that the residence of Mr. Lloyd-George was blown up during his absence on the Continent, and that Mrs. Pankhurst has boasted openly that she and her followers are responsible for the deed. The contents of mail boxes have been destroyed by acid, and many other acts of vandalism have been committed by these ladies whose actions should deny them the consideration generally accorded to their sex. Drastic measures appear to be necessary to curb the destructive fury of these misrepresentatives of the 'gentler' sex.

MEXICO also presents problems of grave importance. Colonel Felix Diaz, who was captured last October at Vera Cruz in the act of fomenting an incipient rebellion against the Madero government, was imprisoned in Mexico City pending a trial by due process of law. While still in prison he succeeeded in perfecting a conspiracy for a rebellion, and by one of those coups that seem impossible outside of summer fiction, captured the arsenal. Then commenced a war in the streets of the city between the forces of Madero and Diaz in which hundreds and perhaps thousands have been killed and much property destroyed. This was no *opéra bouffe* affair. Machine guns, shrapnel, and even heavier ordnance were used, and all efforts to confine the fighting to a restricted area were unavailing. Finally Señor Madero was 'prevailed upon' to 'resign' and General Huerta was 'appointed' provisional president. A law much used under former president Porfirio Diaz known as *ley fuga* was appealed to and first applied in the shooting of Gustavo Madero, a brother of the ex-president, on the plea that he was trying to escape. Time for recovery from this cold-blooded assassination had hardly elapsed when Señor Madero and Señor Suarez, the latter having been vice-president under the Madero régime, were shot at midnight and the story given out that it was due to an accident while they were being taken to the penitentiary. This story has been received by the world with marked incredulity. According to precedent, it would appear that the next act in the drama would be the summary disposal of General Huerta and his adherents by Colonel Diaz. No move toward intervention is likely to be made by the United States Government, although troops and warships have been mobilized and are awaiting orders. The condition of affairs since Señor Porfirio Diaz was deposed has been deplorable, but a war with Mexico would be infinitely worse. When the amiable gentlemen heading the various factions in Mexico succeed in killing one another off, let us hope for the rise of a strong man who will restore peace for our troublesome neighbor on the south.

DEFEAT of the Rodenburg bill providing an appropriation of $2,000,000 for an exhibit by the Federal Gov-

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ernment at the Panama-Pacific Exposition has been regarded with mixed feelings in California. Mr. Kent, one of the representatives in Congress from California, led the opposition to the bill, and it was due principally to his efforts that the bill was defeated. A clause in the bill providing that the direction of the exhibit should be in charge of seven commissioners was responsible for the opposition. It was pointed out that the expense for salaries of these commissioners would amount to $200,000, and a smaller ex-officio commission was suggested. All attempts to modify the bill were unavailing, for commissions are favorite roosting places for 'lame ducks', of which there are just now an unusual number, and the bill itself went down to defeat. Hope that steps may be taken at this session to provide for an exhibit by the Federal Government has not altogether gone, however, as an amendment to the sundry civil bill has been introduced in the Senate providing $1,500,000 for an exhibit and a commission of three at $7500 per year each. This bill has been referred to the Senate Committee on Industrial Arts and Expositions, favorably reported, and passed in the Senate by acclamation. It is hoped that it will meet no oposition in the House, and that it may be finally passed before Congress adjourns.

TRANSPORTATION facilities within the city of San Francisco to provide for the crowds that are expected to visit the Fair is an even more serious matter than the Federal Government exhibit. The fate of the franchise amendment submitted to the voters has already been noted in our columns. The United Railroads company, which operates nearly all of the street railroads within the city of San Francisco, applied to the State Railroad Commission for permission to issue $2,350,000 of 6 per cent 5-year notes, to provide funds for betterments and extensions. The Commission denied the application and took advantage of the opportunity to 'read the riot act' concerning the methods whereby the company was financed. The remarks of the Commission make interesting reading, but contain comparatively little that is comforting to those who appreciate the gravity of the transportation problem with regard to the success of the Exposition. After a series of conferences between the officials of the city and of the Exposition company, a tentative plan has been outlined that will go far toward removing the difficulties in the present situation. It is proposed to construct a municipal railway on Van Ness avenue between Market and Bay streets which will cost about $292,000. This work may be undertaken immediately, as a balance of $300,000 remains in the Geary street railway fund. Another bond issue is contemplated to provide additional cross-town lines in order that transportation facilities may be adequate by the time the Exposition opens its doors. The city engineer is preparing a comprehensive report concerning ways and means, and which will be submitted to the Board of Supervisors within about thirty days. In the meantime, the State Board of Harbor Commissioners are considering the feasibility of extending the Belt Line railway around the embarcadero and along the seawall to the fair grounds. This would take care of the transbay visitors and help the general situation immensely. The decision of the Supervisors as to the course to be pursued will be awaited with great interest.

TROUBLES in transportation circles are not confined to street railway affairs by any means. The California

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phases of the unmerging of the Harriman lines are being taken up by the State Railroad Commission, and the indications are that they will insist on modification of the plan said to be acceptable to the Attorney-General and the Supreme Court. Much opposition has developed toward the acquisition of the Central Pacific by the Union Pacific, and the situation is further complicated by the fact that Mr. Wickersham, the present Attorney General, will go out of office in a few days, and the attitude of his successor is unknown. Another interesting feature is that the Western Pacific Railroad has appeared before the Railroad Commission asking for a right equal to that possessed by the Union and Southern Pacific to use the Central Pacific tracks between Sacramento and San Francisco by way of Benicia. It must have been interesting to the Harriman officials, who had been indulging in what may be termed a little family affair, to contemplate the insertion of the oar of a rank outsider who pipes up, "Me too," while the melon is being cut. The Commission has signified its approval of the contention of the Western Pacific for equal rights in the premises and wired a summary of its opinion to the Attorney General at St. Louis. It would be idle to attempt to forecast the result of this three-sided case.

WATER has been turned into the Los Angeles aqueduct. Evidently the aqueduct officials are not superstitious, as on February 13 the gates at the intake were lifted and the clear mountain water started on a 60-mile journey to the Haiwee reservoir, whence it will undertake another journey of 240 miles to serve the people of Los Angeles. By May 13 it is expected that every section of the aqueduct will be filled. A party including Messrs. J. B. Lippincott, O. W. Peterson, Charles Lee, Roderick Mackay, and H. A. Van Norman, all of the engineering staff of the aqueduct project, opened the gates that admitted water for the first time to the great aqueduct that represented so many months of their time and labor. At first the water was only permitted to flow through at the rate of about 130,000,000 gallons per day. After two days, the gates were thrown wide open and the entire flow of the Owens river was turned into the canal. The still unfinished work south of Haiwee consists of about one-half mile of excavation, 750 feet of conduits, 3 miles of concreting, and 2000 feet of tunnels in San Francisquito canyon, all of which will be done within four weeks. The reservoir is seven and one-half miles long and from one-half to one and one-quarter miles wide. The dam at the north end is 1890 feet long and 46 feet high. The lower dam is 1500 feet long, 80 feet high, and 450 feet wide at the base, and is of the earth-fill type, requiring 600,000 cubic yards of material. The core wall is made of clay and is 8 feet wide, 1000 feet long, the greatest depth being 120 feet. The keenest interest is felt on all sides as this great work nears completion, and all unite in extending congratulations to Messrs. Mulholland, Lippincott, and their staff as the last lap in the race approaches, signifying a great work well done.

RECENT events lead us to the belief that San Francisco also may eventually have an adequate water-supply. News has come that the Board of Army Engineers which, at the instance of Mr. Walter Fisher, Secretary of the Interior, has been making an independent investigation of possible sources of water-supply for San Francisco, has made a report favorable to the Hetch-

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Hetchy project. As a whole, the report agrees with that of Mr. John R. Freeman, except that his estimate of cost is declared to be too low. The difference amounts in all to about $15,000,000, which it must be admitted is a tidy little sum in itself. The Army Board estimate calls for an expenditure of $37,501,000 for the first installation of 160,000,000 gallons per day; $13,910,800 for the second installation of 80,000,000 gallons; $25,955,200 for the third installation of 160,000,000 gallons; total installation, 400,000,000 gallons per day for $77,367,000. Despite the increased estimate, the Hetch-Hetchy source is $20,000,000 cheaper than any other source. The Board says that the statement of the Spring Valley Water Company to the effect that 160,000,000 gallons additional daily supply can be developed from coast streams, Alameda creek, Calaveras reservoir, and other sources, is in error, and that the greatest quantity that might be expected from these sources is 131,000,000 gallons. The recommendations of the Board, in brief, call for the purchase of the Spring Valley Water Company for $35,000,000 to $40,000,000; further development of this company's system to about half the extent proposed by the company, $10,000,000; purchase of water systems of communities outside of San Francisco, no estimate made; construction of Tuolumne system as proposed by San Francisco to be extended over about 50 years, $77,000,000. Against these expenditures there will be developed 115,000 horse-power having an estimated capitalized value of $45,000,000. City officials are feeling jubilant over the outcome and expect that Mr. Fisher will issue the necessary permit within a week. Steps are also to be taken to make assurance doubly sure by introducing a bill in Congress providing for a grant to the city of San Francisco of the rights conveyed under the terms of the permit in order that there may be no repetition of the reversal of a permit by any Secretary of the Interior that had previously been granted by his predecessor in office. It is to be hoped that the purchase of the Spring Valley Water Company's property may be consummated by the time the Hetch-Hetchy matter is settled. A sigh of relief will go up from the entire Bay district when the dirt begins to fly.

ACTION of the California Railroad Commission in denying the application of the Midway Gas Company for a certificate of public convenience and necessity to deliver natural gas from the Midway field to Los Angeles is greatly to be regretted. The reasons advanced by the Commission for taking this action were that the Midway Company would drain the natural gas from land now in litigation between the Federal Government and the Southern Pacific Company; that a monopoly of all sources of natural gas in the Midway field would be established; and absolute control of the sale of gas would be exercised. The Commission states further that the monopolistic control would also be extended to the distribution of gas within the city of Los Angeles by reason of special prices to favored distributing companies, and by agreements as to prices at which the gas will be sold to consumers. The decision renders temporarily valueless the 125-mile pipe-line that was built at a cost of more than $1,000,000 and deprives the people of a bountiful supply of cheap gas. It is likely that recourse will be had to the courts in order to find a solution of the difficulty, although it is still possible that the application may be amended so as to be acceptable to the Commission.

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Pressure Limits of Overhead Electric Transmission Lines

By ALFRED STILL*

IN this article the present position of overhead transmission line design will be considered from the point of view of insulation. This includes such matters as choice and arrangement of insulators, and spacing of wires. The loss of power through leakage in the air at high pressures, and means of determining the working pressure beyond which such losses would become excessive, will also be dealt with.

Insulator Materials.—The material most commonly used for insulators on high-tension overhead lines is porcelain; but glass, which is cheaper than porcelain, may sometimes be used to advantage on the lower-voltage lines. Insulators made of special molded materials such as 'Electrose' have the advantage over both glass and porcelain in that they are lighter in weight and less liable to fracture from mechanical shocks or high-pressure discharges. This material is used in preference to porcelain by the Canadian Niagara Power Co. on its high-voltage transmission lines. Glass is a material of high resistance and dielectric strength and makes excellent insulators for pressures up to about 20,000 volts. The fact that it is pervious to light tends to discourage spiders and cocoon-spinning insects, which ordinarily find their way to the interior of insulators; but, on the other hand, more moisture will condense on the inside surfaces of glass than on porcelain insulators, thus attracting dust and dirt. Glass cannot withstand great and sudden changes of temperature so well as porcelain.

Design of Insulators.—The design of an insulator, to comply with any given specification, is a matter which concerns the manufacturer, who has been compelled of late years, owing to the rapid increase of working pressures, to devote his attention to the principles underlying the correct and economical design of insulators for high-pressure lines, and who is therefore something of a specialist on this particular subject. The transmission-line engineer should understand the principles underlying the correct design of overhead insulators; but it is suggested that, however great his knowledge of the subject, he will be well advised to leave details of design to the manufacturer, and even to use standard types when possible.

The design of insulators for the lower voltages is a comparatively simple matter, and the difficulties increase in proportion to the increase of pressure, although the introduction of the suspension type, which permits of many units being connected in series, considerably simplifies the problem so far as the higher pressures are concerned.

It is important to bear in mind that every insulator is necessarily a more or less complicated condenser, and it can generally be considered as a num-

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ber of separate condensers in series, the dielectric being alternately air and porcelain. The current passing from line to ground is partly a leakage current over the surfaces (the leakage *through* the porcelain being generally negligible), and partly a capacity current. This capacity current spreads itself over the high resistance surfaces of the insulator material in a way which will depend upon the surface conductivity and on the spacing and disposition of the various parts. It is well to keep the electrostatic capacity as low as possible, but it is of equal if not greater importance so to distribute it by a scientific arrangement of the component parts that abnormal stresses will not occur locally, as these might puncture or damage the insulator at one particular part, while a more carefully designed insulator of lighter weight may withstand a greater total breakdown pressure, because proper attention has been given to this important matter of capacity distribution. The effect of rain on the exposed surfaces of an insulator is to increase the capacity, and this will generally lower the flash-over point; but the increased surface conductivity has the effect of equalizing the potential distribution; and in the case of a large number of condensers in series, such as occurs especially with the suspension type of insulator, it has actually been observed that this equalizing of the potential distribution may cause the flash-over pressure of the wet insulator to be no lower than the flash-over pressure of the same insulator when dry.

If I is the charging current passing through a condenser, and E the potential difference causing this flow of current, the relation between the capacity, C, and these two quantities is $E = \frac{I}{C}$ in the case of an alternating current of definite frequency.

When a number of condensers are connected in series, the current, I, is the same through all the condensers, and the potential difference across any one condenser is therefore inversely proportional to the capacity. This is one of the main points to bear in mind in the design of insulators for high voltages.

With the pin type of insulator, a number of sheds or petticoats hanging close to the pin, with small air spaces between them, will not be effective, because, although the leakage path may be long, the capacity is high. The air spaces between the partially conducting surfaces of the porcelain may, in such cases, be little thicker than the porcelain sheds, but the dielectric flux-constant of air is only about one-fifth that of porcelain. The remedy consists in spreading the petticoats away from the pin, the outer shed in some designs being almost horizontal. This outer shed has, in some cases, been replaced by a metal shield. The proposal to depart to this extent from previous practice was made by a firm of German manufacturers,[1] and it is the result of a scientific study of insulator promlems. Apart from the advantage of lightness, which permits of a thin metal shed being made of larger diameter than would be permissible if the material were porcelain, the charging current will spread itself more uniformly over the surface of the outer shed, and so prevent the concentration of potential at the point where the conductor is tied to the insulator. An insulator of this type may flash over a somewhat lower pressure than if the upper hood were of porcelain, but under wet con-

[1]The Hermsdorf Porcelain Company.

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ditions, the flash-over pressure may be higher.

With the *suspension type* of insulator, the conductor is hung below the point of support (which is usually grounded) at the end of a string of insulator units connected to one another by metal links. The potential difference which will cause a flash-over or break-down on such a series of insulators will not be in direct proportion to the number of insulators in the string. This is due to the unequal distribution of the potential differences, which is again a question of relative capacities. The design of the individual units may appear to be good, and yet a string of such insulators if these are not specially designed to fulfil certain requirements, may give surprisingly unsatisfactory results. A factor of importance is the ratio $\frac{\text{mutual capacity}}{\text{capacity to ground}}$ which determines the potential distribution; and this ratio will depend not only on the shape and size of the porcelain units, but also on the metal caps or means of attachment, and the spacing between units. With increasing separation between the units, the flux density at the points of attachment diminishes up to a certain distance at which it becomes constant, notwithstanding any further increase of the separation. F. W. Peek, Jr., in his able paper read before the American Institute of Electrical Engineers[2] uses the term 'string efficiency' to denote the ratio

$$\frac{\text{arc-over voltage of } n \text{ insulators}}{n \times \text{arc-over voltage of single insulator}}$$

and this is a very convenient term for use in comparing strings of different insulators, each consisting of a series of units of one particular size and shape.

In actual tests made by Mr. Peek, the dry arc-over required 1¾ times the pressure of the wet arc-over on a single unit; but, on a string of nine such units, the wet and dry flash-overs occurred at the same voltage. The 'string efficiencies' of these insulators on the dry test were as follows:

No. of units in series.	Flash-over voltage.	Efficiency, %.
1	74,000	100
2	137,000	93
3	186,000	84
4	238,000	80.5
5	281,000	76
6	318,000	72

Another series of tests, quoted by W. T. Taylor,[3] gives efficiencies as below:

No. of units in series	Flash-over dry test	String efficiency, dry	Flash-over wet test	String efficiency, wet
1	90,000	100	56,000	100
2	160,000	89	90,000	80
3	220,000	81.5	130,000	77.5
4	274,000	76	175,000	78
5	310,000	69	220,000	78.5
6	340,000	63	265,000	79

When the mutual capacity is small relative to the ground capacity, there soon comes a point beyond which it is useless to put more insulators in the string. Short strings, of well designed and properly spaced units, will often be more effective and less costly than a longer series of insulators of which the single units may have excellent insulating properties, but which have not been designed for the particular requirements on scientific lines. It is sometimes possible to increase the arc-over voltage of a string of insulators by *reducing* the distance between consecutive units; a fact that it is difficult to understand unless the importance

[2] *Proc.* A. I. E. E., Vol. XXXI, No. 5, May 1912.
[3] *Journal* Inst. E. E., Vol. 46, No. 207, May 1912.

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of the proper capacity distribution has been realized. A well arranged string of properly designed units not necessarily similar in shape and size (in fact preferably not identically of same size), is less liable to damage by lightning and kindred phenomena than a series of insulators of low 'string efficiency.'

It is well to bear in mind that an insulator may, and does, behave differently when subjected to high frequency charges as induced by lightning disturbances, than when the difference of potential is applied at the normal frequency of the transmission line. The distribution of potential among a number of condensers in series has already been referred to, and this should be independent of frequency; but a high tension insulator consists of many capacities in series with resistances, such as the leakage paths through the body of the material and over the surfaces, and the distribution of the total potential drop across a condenser and resistance in series, even if the latter may be considered non-inductive, is very different at high than at low frequencies. This is probably one of the chief reasons why insulators that will flash over rather than puncture on tests conducted at the ordinary line frequency, will sometimes fail through puncture during atmospheric electrical disturbances.

Pin Type Insulators.—This type of insulator is used for pressures up to 60,000 volts, but the suspension type, made up of two or more units, will generally be more satisfactory and economical for pressures above 50,000 volts. The pin type of insulator becomes too heavy and costly when designed for the higher voltages, and, owing to the great length of the supporting pin the bending moment near the point of attachment to the cross-arm tends to become excessive.

Wooden supporting pins are not recommended for high tension work; they are rarely used on lines working at pressures above 33,000 volts. Metal pins are generally preferable.

Fig. 1. shows the sparking distances as usually measured. The dotted line on the left side of the drawing shows the length of path on a dry flash-over. When the exposed surfaces of the insulator are wet with rain, these surfaces are looked upon as conductors, and the flash-over distance is the sum of the separate distances A, B, and C; the lines A and B being usually drawn at an angle of 45° to the vertical. In this particular case, the line C is also drawn at 45° because the metal pin is surrounded by a porcelain base. The length of the pin should be such that the distance E to cross-arm is slightly greater than the sparking distance C from edge of inner petticoat to pin.

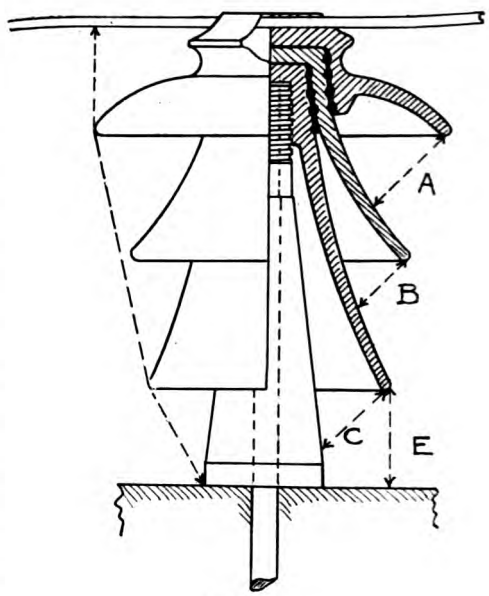

FIG. 1.

The flash-over distances as measured

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on actual insulators of the pin type are approximately as given below.[4]

Voltage, R.M.S. value.	Flash-over distance, inches.
40,000	3
60,000	4½
80,000	6⅜
100,000	8½
120,000	11
140,000	14
160,000	18¼

Fig. 2, 3, and 4 are illustrations of typical pin-type insulators as made by R. Thomas & Sons of East Liverpool, Ohio. The leading particulars relating to these insulators, as furnished by the makers, are as follows:

	Fig. 2.	Fig. 3.	Fig. 4.
Dry-test voltage	80,000	90,000	150,000
Rain-test voltage	50,000	60,000	100,000
Leakage distance, in.	12½	18¾	42
Arcing distance, in.	4½	4⅜	9½
Net weight each, lb.	4½	8¼	24½

Suspension Type Insulators.—Apart from the great advantages from the point of view of insulation, which are obtained by suspending the conductor from a string of insulators connected in series, this arrangement, as now generally adopted for pressures above 60,000 volts, has the further advantage that the conductor is less liable to be affected by lightning disturbances, since, at every point of support, the wire is hung *below* the attachment to the supporting structure which, in almost every instance is a well grounded steel structure. Another advantage is the comparative flexibility of the attachment, which very considerably diminishes the possibility of crystallization of the conductor material, such as is liable to occur when the wire is rigidly attached to the pin type of insulator; this

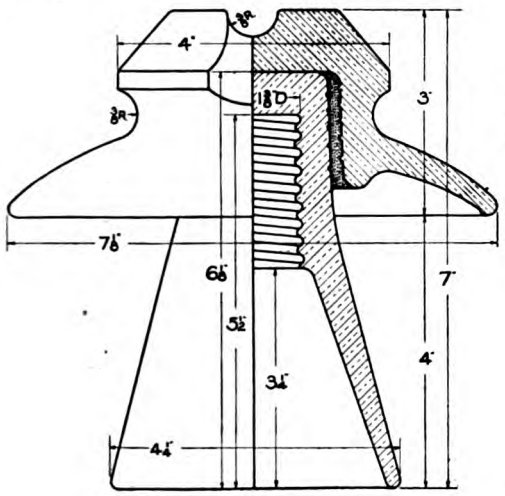

FIG. 2.

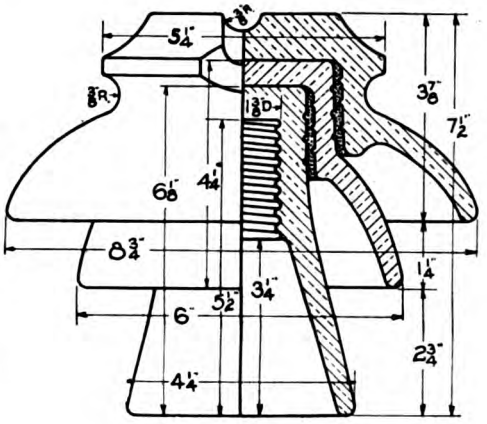

FIG. 3.

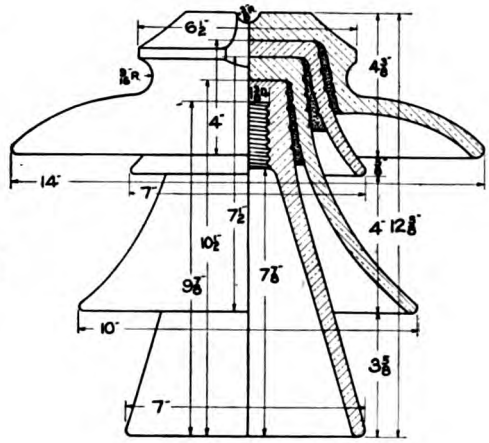

FIG. 4.

[4]Average figures taken from curves given by J. Lustgarten in the *Journal* of the Inst. E. E., Vol. 49, No. 214, July 1912.

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effect being more noticeable with aluminum than with copper.

In designing cross-arms for the attachment of the suspension type of insulator, it is not necessary to pay much attention to torsional stresses, which, however, must be carefully considered when pin-type insulators are used on heavy long-span lines; but, on the other hand, taller towers are necessary with the suspension type of insulator. An-

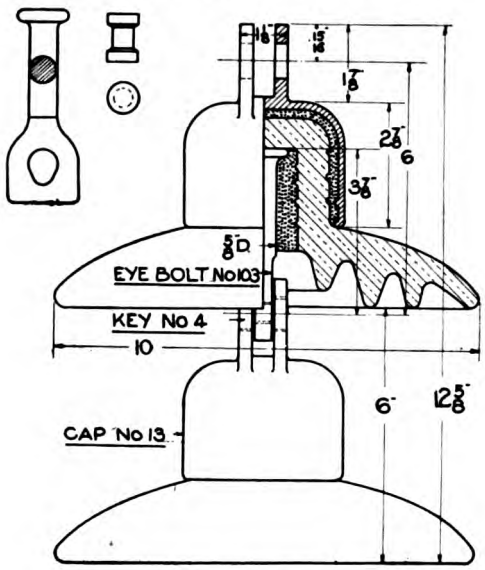

FIG. 5.

other possible disadvantage is the wider spacing between wires generally adopted when this type of insulator is used; and it is certain that rather more skill and experience are necessary in the stringing of the conductors than when pin-type insulators are used.

It is usual to sling the wires in the first instance from snatch-blocks attached to the cross-arms of every tower over a distance of about a mile, or between anchoring or corner towers, and then draw up tight; the conductor being subsequently transferred at every point of attachment from the snatch-block to the permanent suspension clamp at the end of the lowest insulator in the series.

In the interlink type of suspension insulator, the porcelain between the metal links is in compression, and in the event of the shattering of the porce-

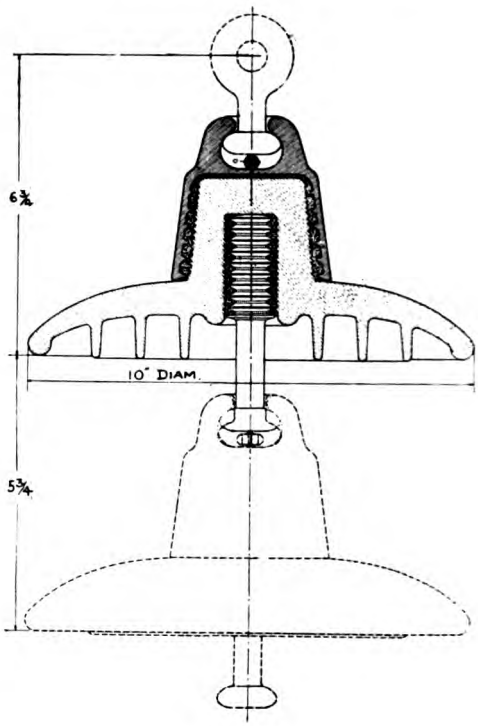

FIG. 6.

lain parts, the conductor remains suspended; but although from the mechanical point of view this type is to be recommended, it is more liable to puncture owing to excessive electric stress in the thickness of porcelain between the metal links, than the more usual type of insulator with cap and bolt cemented to the porcelain parts as shown in the accompanying illustrations.

Fig. 5 shows an insulator manufactured by Messrs. R. Thomas & Sons, and Fig. 6 is an insulator of generally similar type made by the Ohio Brass Co., of Mansfield, Ohio. A string of

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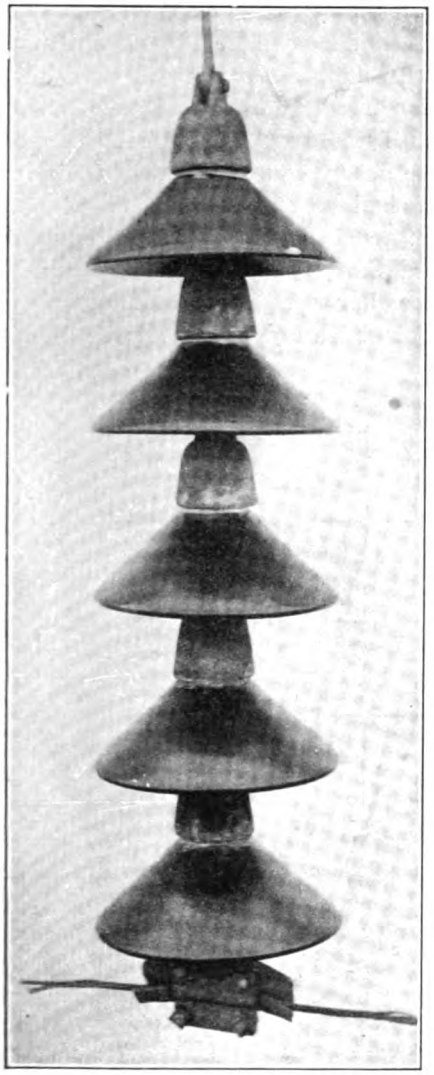
ten insulators as illustrated in Fig. 6 is being used by the Eastern Michigan Power Co. for a working pressure of 140,000 volts. The weight of each unit is 9¾ lb. net. The flash-over dry is 92,000 volts, and wet, 53,000 volts for



TWO-PART INSULATORS FOR 108,000-VOLT LINE, SIERRA & SAN FRANCISCO POWER CO.

the single unit. The photograph here reproduced shows a series of two-part insulators as supplied by the Locke Insulator Manufacturing Co. for the 108,000 volt line of the Sierra & San Francisco Power Co., the first transmission line on the Pacific coast to use the suspension type of insulator.

Weight of Insulators.—It is convenient to know the approximate weights of porcelain insulators for estimating cost of handling and freight, and for determining the loads to be carried by supporting structures. The following average figures will be found sufficiently accurate for calculations in connection with preliminary estimates.

Working voltage.	Wt. of insulators, pounds.
20,000	3
40,000	11
60,000	23
80,000	40
100,000	60
120,000	80
140,000	100

Entering Bushings.—When overhead high-tension conductors have to be brought into buildings, the design of insulating bushings should receive careful consideration. The fact that every bushing acts as a condenser or series of condensers between wire and ground, must steadily be recognized, just as in the case of the pole line insulators, except that the effect is even more marked in connection with bushings entirely surrounding the conductor than with insulators that support the wire at one end only.

When the climate and weather conditions are favorable, it is well to avoid bushings entirely. In such cases, the wires cannot be brought down through the roof of the building, but they must enter at the side; a suitable protecting hood or roof being placed above the wires on the outside of the building.

The smallest dimension of the opening in brick, stone, or concrete wall, according to usual practice, should be as follows:

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For working line pressure of:	Feet.
20,000 volts	1¼
40,000 volts	2
60,000 volts	3
80,000 volts	4

On each side of the wall opening, the conductor is carried by line insulators, of the pin or suspension type, as the voltage may require, these being so arranged as to maintain the conductor in the centre of the opening, with a slight downward incline toward the outside of the building to prevent rain-drops being carried to the inside.

When bushings are used, these must necessarily be thicker at or near the centre where the ground potential is brought up close to the conductor than at either end. Fig. 7 shows a porcelain bushing built up of four parts, as supplied by the R. Thomas & Sons Co. and suitable for a working pressure of 70,000 volts.

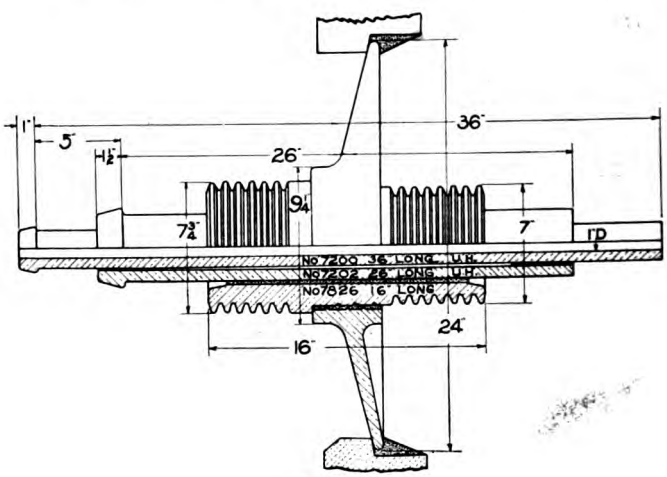

FIG. 7.

In the case of a roof bushing, permitting of the conductor passing vertically downward to the inside of the building, a hollow elongated barrel-shaped insulator (that is, of greater diameter at centre, where it is supported on the outside, than at the two ends) filled with an insulating substance of higher specific inductive capacity and greater dielectric strength than air, makes a satisfactory arrangement provided there is no danger of the oil or other insulating filling leaking out of the containing shell. A good insulating oil will frequently give good results, but it is liable to leak out at the joints, and, moreover, the use of oil calls for a larger and heavier bushing than if the filling has a specific capacity more nearly equal to that of the porcelain shell (porcelain being the material most generally used). It will be understood that if the substance filling the space between metal conductor and hollow bushing had the same specific capacity as the material of the bushing, there would be no change in the potential gradient at the inner surface of the bushing. Thus, the specific capacity of air being 1, porcelain is 4.4, while sulphur is 3.9 (not very different from that of porcelain), and a petroleum oil will be about 2. The thickness of the porcelain shell and the distance between inner surface of shell and conductor surface should be proportioned in accordance with the insulating ma-

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terial intended for use as a filling.

The arrangement shown in Fig. 8 is bad. Here the thickness of the porcelain bushing is large compared with the air gap between wire and inner surface of bushing, the result is that a brush

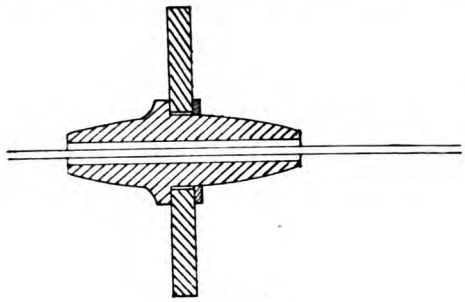

FIG. 8.

discharge between wire and bushing is very liable to occur, the potential gradient near the surface of the wire being greater than if the porcelain bushing were entirely removed.

Condenser Type of Bushing.—By separating thin concentric layers of insulating material by tubes of tin-foil or other metal, and so proportioning the *lengths* of the tin-foil tubes that the *areas* remain the same, notwithstanding the variations in diameter, it is possible to design a bushing which virtually consists of a number of condensers of *equal* capacity all connected in series. In this manner the potential gradient can be made uniform throughout the thickness of the insulating bushing. Commercial entering bushings and transformer terminals have for some time past been built on this principle. The design of such terminals is not quite so simple a matter as this brief reference to the main principle involved might suggest, but the commercial insulators of this class have, on the whole, given reasonably good results. Before considering such matters as factors of safety, spacing between wires, and probable limits of pressure on power transmission lines, it will be well to review briefly what is known about the brush discharges and corona formation which are liable to become important factors when transmitting at the higher voltages.

Formation of Corona, and Accompanying Losses of Power.—When the pressure on an overhead transmission system exceeds a certain critical value depending upon the spacing and diameter of the wires, there will appear on the surface of the conductors a halo-like glow to which the name 'corona' has been given. Apart from this luminous effect, the appearance of the corona is accompanied by a certain loss of power proportional to the frequency and the square of the amount by which the pressure between conductors exceeds a certain value known as the disruptive critical voltage. If the distance between outgoing and return conductors is comparatively small (less than fifteen times the diameter of the wire) there will be a spark-over when the disruptive critical voltage is reached; but with the greater separation such as occurs on practical high-tension transmission lines, the effect of the high potential at the conductor surface is to break down the resistance of the air in the immediate neighborhood of the conductor surface. In this way a luminous cylindrical coating of air, acting as a conductor of electricity, is formed, the diameter of which will depend on the amount by which the actual value of the applied potential difference between wires exceeds the disruptive critical value of the potential difference. The result is equivalent to an increase of the diameter of the conductors, thus raising the value of the voltage necessary to break down new concentric layers of surrounding air, until it is approximately equal to the

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voltage impressed on the wires. During the last few years much light has been thrown on the formation and effects of the corona. Among the earlier workers in this field were C. F. Scott, Harris J. Ryan, J. J. Thomson, H. B. Smith, Signor Jona, Lamar Lindon, E. A. Watson, and, among the latest investigators, Mr. Whitehead[5] and F. W. Peek, Jr.[6]

The more important features and effects of the corona of interest to the practical engineer may be summarized as follows:

1. The loss due to leakage of current from the conductor into the surrounding air is practically negligible for pressure values below the disruptive critical voltage; no account need be taken of such leakage on A.C. circuits operated at pressures below 44,000 volts. On 80,000 volts, however, the loss may be appreciable, and a visible corona may even be formed if the wires are small in diameter.

2. The current passing from the wires into the air on an alternating system is an energy current in phase with the pressure.

3. On A.C. systems, the critical break-down voltage will depend upon the maximum value of the e.m.f. wave, and therefore on the 'form factor.'

4. The break-down voltage — or, more properly, the disruptive critical voltage—is determined by the potential gradient at the conductor surface; it is therefore dependent upon the diameter and spacing of the wires; being higher with the larger diameters and spacings; it is also dependent upon the density of the air, and therefore on the temperature and barometric pressure.

5. The loss of power due to corona formation is proportional to the frequency (within the usual commercial range), and to the square of the excess of line voltage over critical voltage.

6. The disruptive critical voltage is highest when the conductor surface is smooth and quite clean. It is lowered by roughness or dirt on the conductors, also by smoke and fog in the atmosphere, sleet on wires and falling sleet, rain, and snow storms, but especially the last. All these causes tend, therefore, to *increase* the corona *losses*.

7. The visual corona occurs only at a pressure above the disruptive critical voltage and is an indication that there is loss of power in the air. When considering the effects of the corona formation on overhead wires, it is convenient, as in the case of the majority of electrical problems connected with transmission lines, to consider each wire separately in relation to the neutral plane or line. Since the formation of the corona depends upon the electric stress at the surface of the conductor, it is the potential gradient in the immediate neighborhood of the wire which, as previously mentioned, is the determining factor in corona formation. This gradient may be expressed by the ratio *volts per centimetre* at the boundary between the surface of the wire and the surrounding air: its actual value being 29.8 kilo-volts. What is known as the disruptive critical voltage for any particular wire under specified atmospheric conditions, is that voltage which produces the disruptive gradient at the conductor surface. It will, as previously mentioned, depend upon the diameter of the wire and the distance of the wire or wires forming the return conductor; also upon the density of the air and, to some extent, upon the surface condi-

[5] *Proc.* A. I. E. E., Vol. 29, p. 1059 (1910).
[6] *Proc.* A. I. E. E., Vol. 31, p. 1085 (June 1912).

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tion of the wire. F. W. Peek, Jr., who is an authority upon this subject, has given us for the disruptive critical voltage between wire and neutral, the formula:

$$e_0 = m_0 d g r \log_e \frac{s}{r} \qquad (1)$$

in which r = radius of conductor in centimetres,

s = distance between centres of the outgoing and return (parallel) conductors,

m_0 = a factor depending upon the surface condition of the conductor,
= 1 for polished wires,
= 0.98 to 0.93 for roughened or weathered wires,
= 0.87 to 0.83 for stranded cables,

d = a factor depending on the air density,
$= \frac{3.92\,b}{273 + t}$
in which b is the barometric pressure in centimetres of mercury, and t is the temperature in degrees Centigrade.

g = the disruptive gradient of 29.8 kv. per centimetre corresponding to the *maximum* value of the alternating current wave. If the cyclic variation is assumed to follow the sine law, then the value to take for g is 21.1 kv. per centimetre, and the value of e_0 then given by the formula will be the root of the mean square, or effective value of the critical pressure (kilovolts to neutral).

The luminosity or visible halo of light surrounding the conductor does not occur until a higher pressure has been reached, the increase over the critical disruptive voltage being dependent upon the diameter of the conductor. Mr. Peek's formula for the visual critical voltage (kilovolts to neutral) is:

$$e_v = m_v d g r \left(1 + \frac{0.301}{\sqrt{r}}\right) \log_e \frac{s}{r} \qquad (2)$$

where the surface factor m_v has the same value as m_0 for wires, and may be taken at 0.82 for a decided visible corona on seven-strand cables. The notation is otherwise as above.

The formula for loss of power in fair weather, *per kilometre of single wire*, as given by Mr. Peek, is:

$$P = \frac{244}{\delta} f \sqrt{\frac{r}{s}} \times (e - e_0)^2 \times 10^{-5} \qquad (3)$$

where f is the frequency in cycles per second, and e is the actual (effective) pressure between wire and neutral, expressed in kilo-volts. The approximate loss under storm conditions is obtained by taking e_0 as 80% of its (effective) value as calculated by formula (1).

For the purpose of the transmission line engineer, it is more convenient to use inch units and common logs within the formulas; and, if the assumption is made that $d = 1$ (which will be true when $t = 25$ and $b = 76$ cm.) and also that, for the usual sizes of seven-strand cables, the value of m_0 may be taken at 0.85, the following approximate formulas, for fair-weather power-loss calculations, may be used:

$$e_0 = 105 R \log \frac{D}{R} \qquad (4)$$

$$P_m = 0.00553 f \sqrt{\frac{R}{D}} \times (e - e_0)^2 \qquad (5)$$

Here R = diameter of conductor in inches.

D = distance between conductors in inches.

P = loss in kilowatts per mile of single conductor.

Practical Example.—Consider a 100-mile, three-phase, 110,000-volt, 60-cycle, transmission on No. 1 seven-strand conductors arranged in the form of an equilateral triangle with 6-ft. spacing.

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What will be the approximate corona loss?

The diameter of the conductor will be 0.33 in.; hence $R = 0.165$.

By formula (4), the critical disruptive voltage is:

$$e_0 = 105 \times .165 \times \log \frac{72}{.165} = 45.7 \text{ kv}$$

By formula (5) the loss of power per mile of single wire is:

$$P_m = 0.00553 \times 60 \times \sqrt{\frac{.165}{72}} \times \left(\frac{110}{\sqrt{3}} - 45.7\right)^2 = 5 \text{ kw. nearly}$$

The total loss to be expected under fair-weather conditions is therefore:

$$5 \times 3 \times 100 = 1500 \text{ kw.}$$

Corona Considered as 'Safety Valve' for Relief of High-Frequency Surges or Over-Voltage Due to Any Cause.—The loss, as calculated in the above example, is not small; but since it is proportional to the *square* of the excess of pressure over the disruptive critical voltage, a small increase of pressure will lead to an enormously increased dissipation of energy in the air. Thus, if the pressure of 110 kv. in the above example be supposed to increase only 10% the total dissipation of power, instead of being 1500 kw., would be 2750 kw. It has indeed been stated that on the 110,000-volt system of the Grand Rapids-Muskegon Power Co., the line loss due to corona discharge actually increases 100% for a 10% rise in pressure.

This property of the corona suggests the possibility of working high voltage transmission lines at a normal pressure in the neighborhood of the critical disruptive voltage where the loss would be inappreciable. An extra high voltage discharge, due either to atmospheric lightning, or to internal causes, will then be largely dissipated in the corona itself. This may, to some extent, account for the fact that fewer lightning troubles are experienced on the very high voltage transmissions than on the lower voltage lines. The insulation of the conductors being such as to withstand, without breakdown pressures, considerably in excess of the disruptive critical voltage of the corona a large amount of oscillating energy can be dissipated in the air before the voltage rises to such a value as to pierce or shatter insulators or damage apparatus connected to the line. On the other hand, too much reliance should not be placed on the corona as a means of dissipating large amounts of suddenly impressed energy; because lightning and similar disturbances, being to a great extent local, must discharge their power locally, and the corona losses over a *short* section of the transmission line cannot under any circumstances be very great.

Factors of Safety, and Tests.—When selecting insulators and deciding upon the spacing and arrangement of conductors suitable for a given voltage, the factor of safety to cover abnormal pressure-rises is a matter of great importance, since it is obviously bad engineering to provide insulation in excess of what experience has shown to be a reasonable safeguard against interruption of service. Generally speaking, the insulators should, when dry, withstand a pressure test of 2½ to 3 times the working pressure to ground, applied for 10 to 15 minutes, and a wet test of not less than 1½ times the working pressure. This would generally be considered too small a margin of safety; but the ratio between test pressure and working pressure will depend upon whether the line voltage is high or low. The following safety factors, representing ratio between wet-test pressure and working pressure are

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generally in accordance with usual practice; but the engineer should use his judgment in a matter of this sort. It is clear that, on the coast, where gales and salt sea mists are prevalent, the factor of safety should be rather higher than in a district where the climatic conditions are more favorable.

Working voltage.	Safety factor. (Wet test.)
20,000	2.5
40,000	2.2
60,000	2.0
80,000	2.0
100,000	1.8
120,000	1.8

As the wet or 'rain' test will give different results, depending on the method of conducting the tests, there should be a clear understanding between the purchaser and manufacturer on this point. A very common specification is that the spray shall be directed at an angle of 45°, under a pressure of 40 lb. per square inch at the nozzles; the flow being regulated to give a precipitation of 1 inch in 5 minutes. The method of attaching test wire and ground connection to the insulator should also be clearly defined. The test pressure is usually measured by means of a spark gap; and the alternating e.m.f. used should conform as nearly as possible to the sine wave.

The striking distances in air between No. 3 *sharp* needles, as given by the Locke Insulator Mfg. Co., are as follows:

Kilovolts.	In.	Kilovolts.	In.
20	1.00	200	20.50
40	2.45	225	23.05
60	4.65	250	25.60
80	7.10	275	28.30
100	9.60	300	31.00
125	12.25	350	36.10
150	15.00	400	41.20
175	17.80		

It will be observed that for pressures above 100,000 volts the gap between needle points is approximately 1 in. per 10,000 volts. The pressures referred to in the table are the effective or root-mean-square values of the test pressure, on the sine wave assumption.

The mechanical strength, or rather the fragility of the porcelain, is sometimes tested by discharging a shot-gun at the insulator, mounted in position on the pole; but unless all insulators on a transmission line are so tested with a view to eliminating those that may be mechanically defective, it is doubtful whether such a test is of much value.

Distance Between Wires.—The spacing of the wires is determined by considerations partly electrical and partly mechanical. With the longer spans, the spacing should be greater than with the short span, apart from voltage considerations. The diagram Fig. 9 will be found to give spacings between conductors generally in accordance with present day practice.

Practical Limitations of Overhead Transmission-Line Voltages.—From the foregoing review of the insulation problems to be met with on long-distance overhead transmissions, it will be clear that manufacturers are now in a position to provide insulation amply sufficient for actual requirements. We have power actually being transmitted at 140,000 volts; and lines have been planned for a working pressure of 165,000 volts. The lines of the Au Sable Electric Co. in Michigan, transmitting power at 140,000 volts, consist of stranded copper conductors ⅜-in. diam. on 500-ft. spans, with a sag allowance of about 12 ft. The shortest distance between conductors is 12 ft., this being the vertical height between the two conductors on one side of the steel supporting towers. There is practically no visible corona, but a buzz or hum, due no doubt to brush discharge, can be heard in the neighborhood of the transmission lines.

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Although no insurmountable difficulties are met in providing ample insulation for these high voltages, it is the engineer's business to provide such insulation as will be justified by economic considerations. It is also his business to determine the voltage of transmission on the same basis, and resist the temptation to experiment in voltages higher than may be justified by commercial considerations.

This article does not deal with costs or economic questions; but at the same time it is well to bear in mind that the economical transmission voltage depends not only on the length of the line, but also on the amount of power to be transmitted; and although a 200,000-volt transmission offers no serious engineering difficulties, the conditions under which a transmission at so high a voltage would be a commercial success, are very seldom encountered in power transmission design.

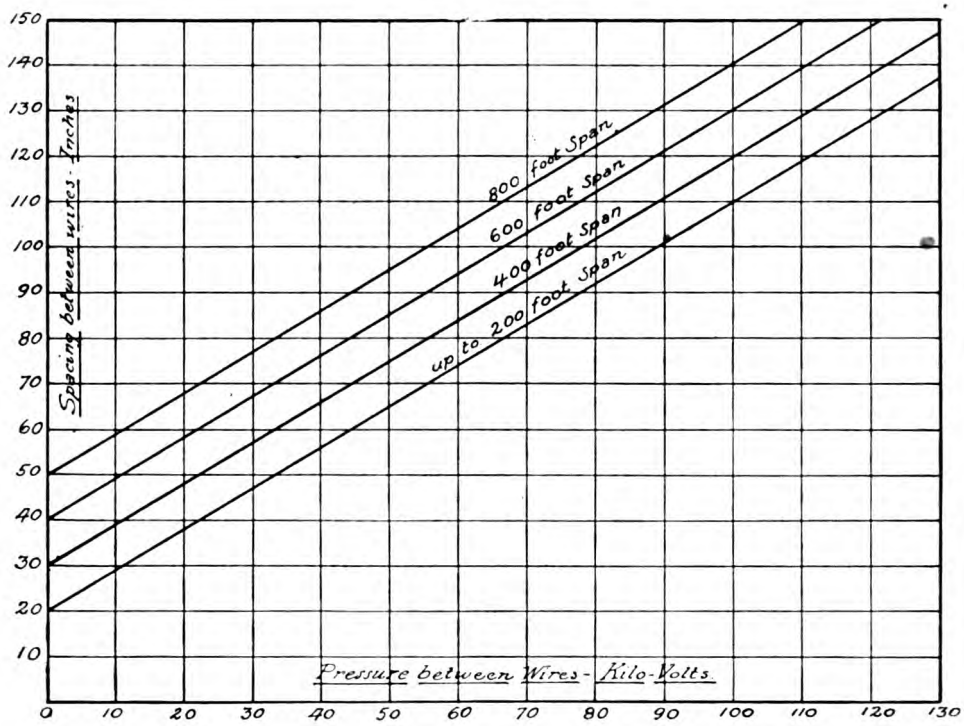

FIG. 9.

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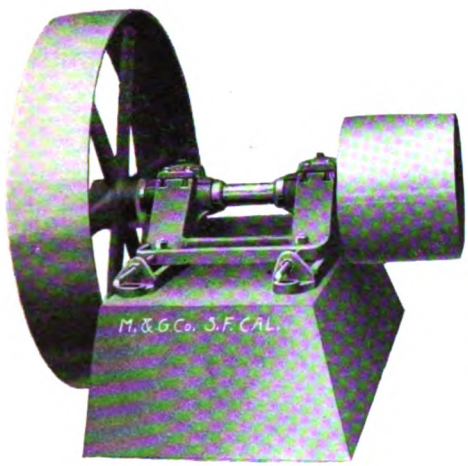
Speed Reducing Gear for Electric Oil Well Drilling

By F. A. WILLIAMSON

THE number of strokes required for the walking beam per minute for pumping different wells varies, with the density of the oil, the amount of sand therein, and the rate of flow of the well. In some cases it seems to be merely a matter of opinion with operators in the same territory. However, the average speed runs from 20 to 24 r.p.m. on the band wheel, which is equal to the same number of strokes on the walking beam. In connecting an electric motor to the well, two methods may be used for reducing speed. First, the back-geared motor, the reduction being obtained through suitable gears mounted on the motor itself, the pulley driving the band wheel direct; second, the belted drive. The first mode of driving would appear the more satisfactory on first consideration. However, under working conditions, practical objections soon made their appearance, not the least of which is the objectionable noise, owing to the fluctuating load where a series of these motors are running. In addition, the wear on the pinion is a factor to be considered.



OIL-WELL COUNTERSHAFT.

It soon became apparent that the belted drive would prove much more satisfactory in pumping oil wells, and the problem became one of designing a countershaft which would be self-contained, with bearings of ample size to withstand the pressure when pulling and cleaning wells. The countershafts now in use give perfect satisfaction, there being about three hundred in operation. The self-contained countershaft consists of 2 wick-oiling boxes cast with a substantial base, the width of which being the same as that of the engine block. The wicks act through capillary attraction, bring the oil from a reservoir of ample capacity cast on the top of the bearing cap and distribute it along the shaft. The bearings caps are set at an angle of 45° in order that they may not sustain the pull of the load. Wick-oiling bearings have worked out to better satisfaction than the ring-oiling type as it was found that the reservoirs of the ordinary ring-oiling bearings, without stuffing boxes, would empty themselves in a very short time owing to

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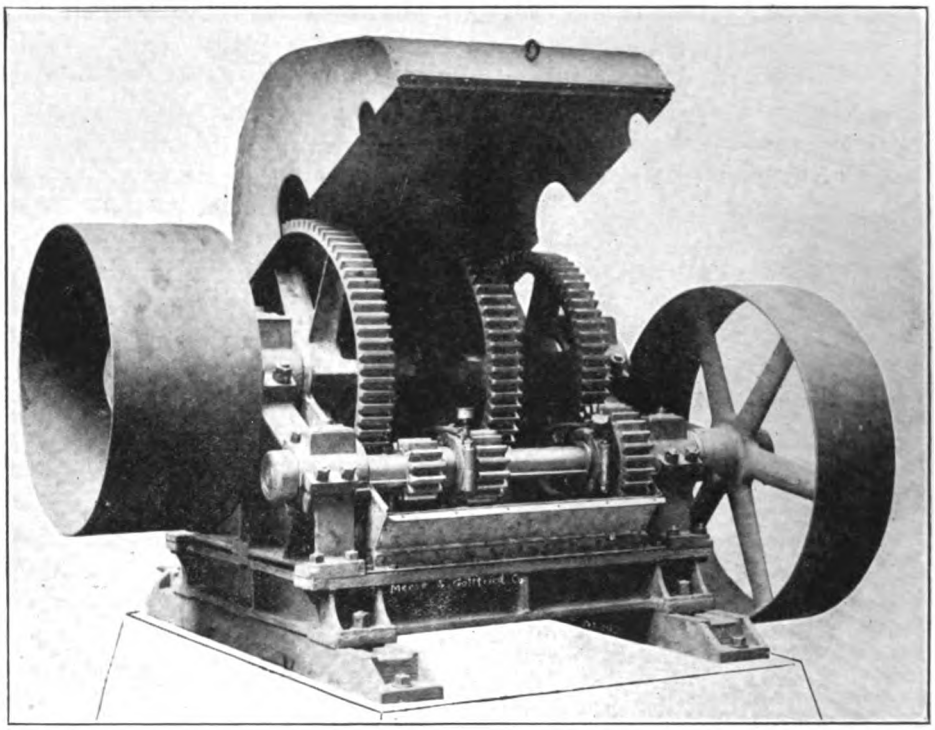
the angle at which they were required to operate. The shafting used is turned and ground steel, and does not heat appreciably even when running at its highest speed in cleaning a well.

The pulleys mounted on each end of the shaft overhang the bearings, and are of a diameter and face to suit the sures a balanced pulley which can be run safely at a high speed.

In actual operation, the countershaft is set on the old engine block or a concrete foundation, and the electric motor, which is erected about sixteen feet away near the sand reel, is belted to the countershaft. Another belt is



THREE-SPEED SLIDING GEAR TRANSMISSION WITH CASING OPEN.

motor speed and horse-power. The present practice is to use a heavy cast iron pulley, 20 in. diameter and 14-in. face, for driving the band wheel, which is 120 in. diameter. The motor-driven pulley which has been found most satisfactory is a special steel-rim pulley having cast iron hub and arms, the steel rim being securely riveted to the arms and the rims subsequently ground true. This produces a pulley absolutely free from shrinkage strain, and the rim being of steel of an even thickness in- connected to the countershaft pulley on the opposite side, which drives the band wheel at the desired speed. To compensate for changes in the length of the belt, due to stretching or contraction on account of the extreme changes in temperature, the countershafts are generally set on adjustable sliding rails.

For pulling a well, which means the removal of the sucker rods and tubing, a higher speed is desired than is used for pumping. This is obtained by doubling the motor speed in the case

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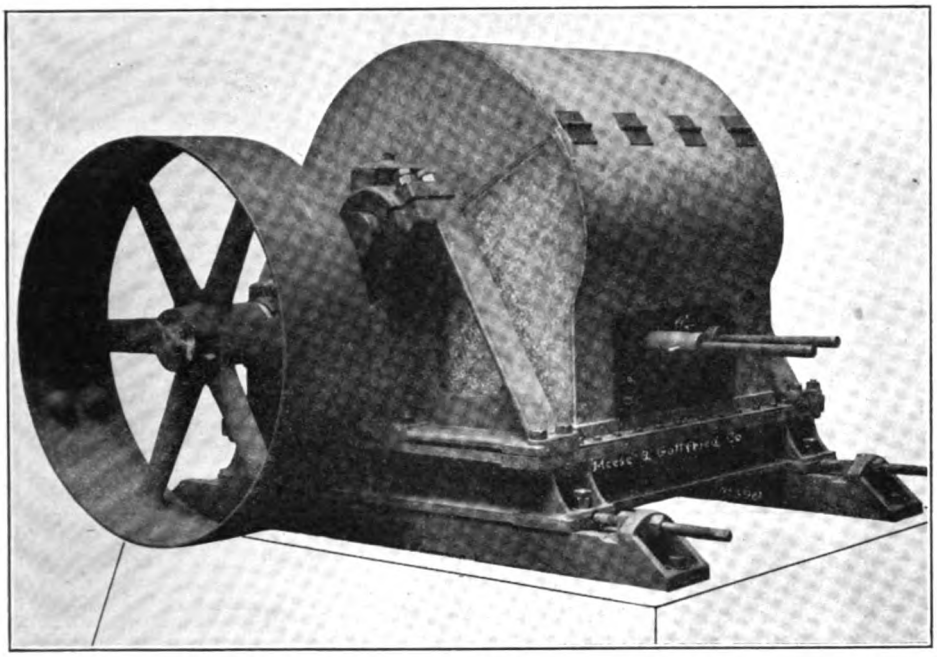
of the two-speed motor, or replacing the motor pulley with a larger one in the case of the single-speed motor. The difference in the length of the belting is compensated for by the adjustment of the motor, which is furnished with a sliding base. When cleaning a well, which consists of running a 'swab' inside the casing, the tubing and sucker rods having been removed, the higher speeds. This speed changer may be compared to the sliding-gear transmission of an automobile, as it is operated in very much the same way. For a territory of medium depth, a two-speed gear has been found satisfactory, whereas for deep territory a three-speed gear is being used. This apparatus consists of two or three trains of gears mounted inside an oil-tight housing. The pinions can be slid in and out of mesh by the operator with the aid of a rod from the 'headache' post. In operation, the motor drives a pulley mounted on the pinion shaft of the drilling gear, the pulley on the gear shaft driving the band wheel, the speeds ranging from 24 to 66 r.p.m. at the full speed of the motor. The lower speeds are used for handling the casing, the intermediate speeds for drilling and the highest speeds for 'spudding in' and 'bailing.'



THREE-SPEED SLIDING GEAR TRANSMISSION WITH CASING CLOSED.

speed is used. In re-drilling wells, or drilling shallow wells, the same speed is used, the band wheel operating at about 48 r.p.m., slower speeds being obtained with the aid of the controller on the motor.

In drilling wells, the method of connecting electric motors is very much the same as in pumping and cleaning, except that a mechanical speed-changer has been found necessary for deep-well drilling so as to make the full power of the motor available at the slower

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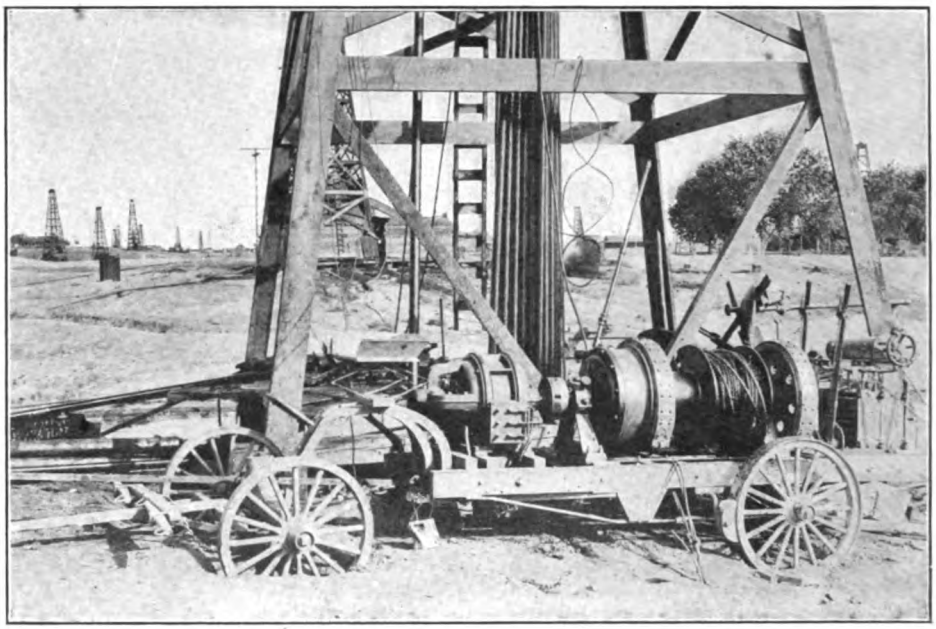
For operation in very shallow territory, such as found in the Kern River oilfields, an electrically-driven portable outfit has been used to good advantage for drilling and cleaning wells. The illustration shows its general arrangement and application, the pumping of the wells being accomplished with the aid of a pumping-jack, operating about twenty-four wells at one time.



CONANT PORTABLE ELECTRIC DRILLING RIG.

The above illustration is especially interesting, as it shows the application of the Conant speed reducer to oil well operations. This device is comparatively new, being the latest development in the line of planetary speed-reducing gears for direct connection to motors and allow of very high gear ratios, several hundred to one if desired, and all from one small compact machine in a direct line of shafting. It consists of an oil-tight casing containing the planetary gears, so arranged that all of the load is carried in balance, and without the short internal shafts supported at but one end, which formed part of all such gearings before this was put into use.

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Oakland Street Improvements for 1912

By WILLIAM J. BACCUS*

A summary showing the length and approximate cost of new street work completed during the second half of the year 1912 is as follows: As the working season for street construction coincides with the limit of the calendar year, I give also a summary of the new construction work for the entire year, together with a statement of the total mileage within the city of Oakland on December 31, 1912, of various classes of improved streets, sewers, and sidewalks.

The estimated total cost of new work, constructed by contract and supervised by my department during the calendar year 1912, is $1,675,522.43. This is a large amount in the aggregate, but in my opinion the money has been wisely expended. I think it would be conservative to say that property values, which reflect the safety, health, and convenience that this work has conferred upon property owners and the general public, have increased by two or three times the cost. This amount has paid for 4.67 miles of permanent pavement, mainly sheet asphalt of the highest class, 17.251 miles of oil-macadam, 81.395 miles of sanitary sewers, 2.841 miles of storm sewers, and 31.392 miles of sidewalk. In addition, the department has improved existing water-bound macadam by reconstructing 2.165 miles as oil-macadam, surface oiling 14.79 miles, and spreading tar over 11.6 miles. This work done by the department is rapidly reducing the amount of plain macadam. In fact, since July 1, 1911, the amount of plain macadam has been reduced from 254 miles to 207.2 miles, which has enabled us to reduce the cost of sprinkling and give better service. Some of the principal items that entered into the new construction are as follows:

Asphalt paving, 825,000 sq. ft., exclusive of railroad work.

Oil-macadam, 3,168,000 sq. ft., requiring about 88,000 tons of macadam rock, 20,000 tons of screenings, and 550,000 gallons of heavy asphaltic road oil, all exclusive of railroad work.

Grading, 314,000 cubic yards.

Concrete gutters, 456,000 square feet.

Broken rock gutters, grouted, 136,000 square feet.

Basalt block gutters, 80,100 square feet.

Brick gutters, 30,700 square feet.

Wooden curb, 140,000 linear feet.

Concrete curb, 61,000 linear feet.

Granite curb, 27,800 linear feet.

It has been the policy of the department to urge permanent pavement in the business district and on main highways only. During 1912 nearly all of the sheet asphalt work was done on streets of this character, in many cases closing gaps that interfered with the full use of pavement already laid, as, for example, on Webster street, Franklin street, 24th street, 20th street, and 22nd street. 12th, 13th, and 14th streets are important thoroughfares on which work was done. During the

*Commissioner of Streets, Oakland, California.

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coming year most of the paving work will be done on main streets leading from the business district of Oakland to important outlying sections, or to other cities. Broadway, Telegraph avenue, and Grove streets are examples of this class of streets on which work will be done, and it would be well to improve Grand avenue, 16th street to the Southern Pacific station, and parts of east 14th street. Oil-macadam, which has now entirely replaced water-bound macadam for new construction, has been laid on residence streets, generally upon petition of a majority of the property owners, or by the owners of new tracts of land.

STREET MILEAGE

(Improved and Unimproved, Dec. 31, 1912)

	Previous reports.	Constructed 1912, July-Dec.	Total, Dec. 31, 1912
Standard asphalt	20.103	2.674	22.777
Bitumen	6.184	0.197	5.987
Asphaltic concrete	1.240	....	1.240
Asphaltic concrete on concrete base	0.137	....	0.137
Hassam concrete	0.211	....	0.211
Wooden blocks	0.410	....	0.410
Basalt blocks	0.057	0.093	0.150
Vitrified brick	0.129	....	0.129
Total pavement	28.471	2.767	31.041
Oil-macadam	17.654	16.649	34.303
Water-b'd macadam	236.462	29.256	207.206
Water-b'd oil surface	28.746	12.817	41.563
Water-bound with tar surface	.....	11.600	11.600
Plain macadam turnpike roads	61.500	2.300	59.200
Plain macadam turnpike, oil surface	4.053	0.589	4.642
Unimproved	143.087	....	131.601
Total dedicated streets	519.956	1.183	521.139
Sewers	287.960	77.810	365.770
Sidewalks	624.355	17.057	641.412

RECAPITULATION

(Street Work Constructed, 1912)

	Miles.	Est. cost.
Permanent pavement:		
January-June	1.903	$183,371.66
July-December	2.767	267,839.77
Total	4.670	$451,211.43
Oil-macadam (including grading, curbing, etc.):		
January-June	2.767	$102,849.69
July-December	14.484	445,848.90
Constructed by depm't.	2.165	.....
Total	19.416	$548,698.59

SUMMARY, JULY TO DECEMBER 1912

	Permanent pavement.		Oil-macadam.		Sanitary Sewers.	
	Miles.	Cost.	Miles.	Cost.	Miles.	Cost.
Public contracts	2.702	$177,584.00	3.958	$119,464.03	53.355	$304,000.98
Private contracts	0.050	5,242.26	10.172	290,703.86	16.642	70,720.83
City contracts	0.015	7,025.71	0.354	7,127.01	5.718	71,215.36
Railroad work (est.)	....	77,987.80	....	28,554.00	....	.....
	2.767	$267,839.77	14.484	$445,848.90	75.715	$445,937.17

	Storm sewers.		Sidewalks.		Miscellaneous
	Miles.	Cost.	Miles.	Cost.	cost.
Public contracts	0.086	$1,222.43	0.350	$2,435.55	.....
Private contracts	1.995	50,927.26	16.491	55,370.47	.....
City contracts	0.014	411.25	0.216	1,469.34	$5,875.53
	2.095	$52,560.94	17.057	$59,275.36	$5,875.53
Total cost					$1,277,337.67

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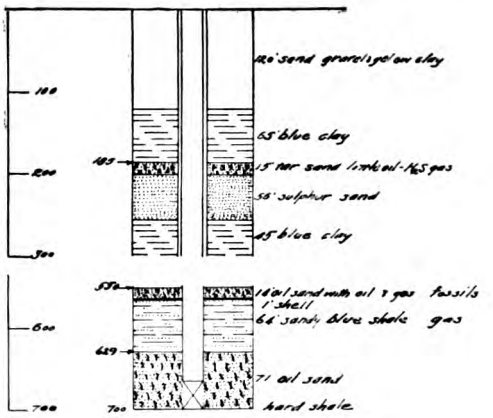
Sanitary sewers:		
January-June	5.680	$43,039.34
July-December	75.715	445,937.17
Total	81.395	$488,976.51
Storm sewers:		
January-June	0.746	$19,721.08
July-December	2.095	52,560.94
Total	2.841	$72,282.02
Sidewalks:		
January-June	14.335	$49,202.99
July-December	17.057	59,275.36
Total	31.392	$108,478.35
Miscellaneous		5,875.53

Estimated total cost of 1912 construction, including all street work, sanitary sewers, storm sewers, sidewalks, grading, and curbing, amounts to $1,675,522.43.

Cementing Off Water in the California Oil Fields

By B. K. STROUD*

ENCROACHMENT of water into the oil-bearing strata is without question the most serious problem that confronts any oilfield. Oil operators the world over, sooner or later must take into consideration the danger of allowing water to penetrate into the oil measures and thereby, in time, ruin their fields. This is particularly true in California, where the formation consists principally of soft shale, clays, and sands, interspersed with an occasional hard stratum of limestone, sandstone, and the like, locally known as shells. The source of water may be above, below, or directly in the oil-bearing strata. In many wells a water-sand has been found to be separated from the oil-sand by only a thin layer of caving shale, while again, in drilling through the oil-sand itself, water has been encountered near the bottom. The accompanying graphic logs will serve to illustrate some of the above conditions. Log No. 1 shows a well in the Lost Hills district of the San Joaquin valley, in which water was found toward the bottom of a 71-ft. oil-sand. Log No. 2 shows a well in the same district, where the water-sand and oil-



Log 1.

sand were found to be separated by 2 ft. of gray sandy shale. Log No. 3 is that of a well in the Midway district, where the water was found 20 ft. above the oil-sand, with only a caving blue shale between the two. Such conditions as these require the most careful

*Universal Oil Co., Wasco, California.

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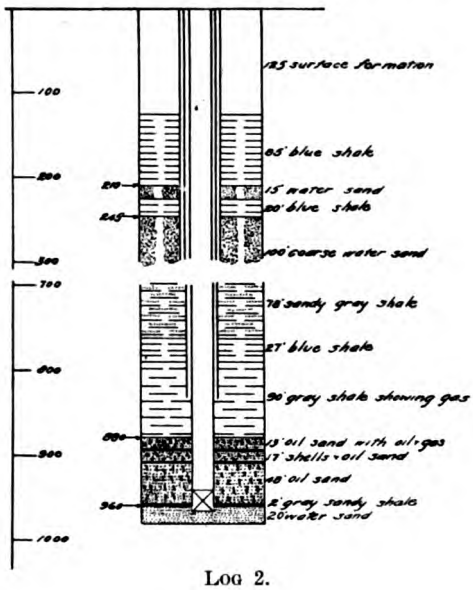
and painstaking work on the part of the operator in order that the source of the water may be discovered and the water excluded from the oil-bearing strata.

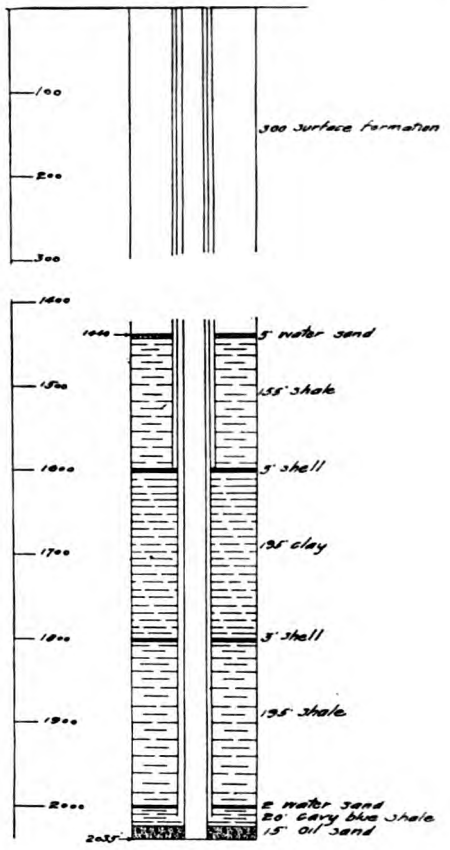
Effective means must therefore be employed to protect the oil-sands from infiltrating water, and it is with the methods used that this article deals. It might be said further, that the California fields differ from the fields of the



Log 2.

Eastern and Middle Western states in that for the latter the formation is generally a hard slate, limestone, or sandstone in which the water can be successfully shut out by simply setting the casing on bottom and proceeding with a smaller drill, thus leaving a shoulder upon which the casing may rest, thus effecting a joint that is water-tight. In contrast with this are the soft clays and shales of California, which in themselves are often unreliable for this purpose.

In early oilfield practice in California it was the custom to set the 'water string' of casing upon a 'shell' of limestone or sandstone, should one be found at the proper point, in order to shut out water. These shells are from a few inches to several feet in thickness, and when hard and strong enough to hold the weight of the casing, are all that is necessary to effect a tight joint. If a



Log 3.

shell was not found in a convenient place, the casing was driven into a bed of clay and then left to stand, so that the mud from the walls of the hole might fall to the bottom and there shut out the water by forming an impervious plug around the casing. By casing is meant the lap-welded screw pipe which has always been used in California. Again, seed bags of rice, grain, or other cereals were often resorted to in the hope that they might expand around

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the casing and form a tight plug. Water, however, began to make its appearance in many of the wells of the older fields, and was found to have broken in through a leak in the casing, or to have come from some source in the sands below, often from a neighboring well. Operators began looking for some method or methods to save the oil measures. Heavier casing was used and it is now the rule rather than the exception for cemented wells to be free from water. The analysis and physical tests of a special California oil-well cement are given herewith. In general, it might be said that there are few wells making water, that cannot be successfully cemented in a manner to save the oil strata from encroachment of water, if done in time. Take, for instance,

SANTA CRUZ PORTLAND CEMENT CO.

CHEMICAL AND PHYSICAL TESTS

METHOD: AS SPECIFIED BY THE AMERICAN SOCIETY FOR TESTING MATERIALS

CHEMICAL ANALYSIS

SILICA	SiO_2		21.50%
OXIDE OF IRON	Fe_2O_3		2.43-
OXIDE OF ALUMINA	Al_2O_3		7.03-
OXIDE OF LIME	CaO		63.70-
OXIDE OF MAGNESIA	MgO		1.76-
SULPHUR TRIOXIDE	SO_3		1.24-
IGNITION LOSS	Loss		1.75-

SPECIFIC GRAVITY 3.122

FINENESS 100M-95.5 200M-74.0%

PERCENT NEAT 23.3 SAND 9.6

SET-INITIAL 2 HOURS 27 MIN

SET-FINAL 4 HOURS 30 MIN

TEMPERATURE AIR 73° F WATER 70°

SOUNDNESS — STEAM 3 H SOUND; BOIL 3 HRS "; AVERAGE — AIR 28D "; SAMPLE — WATER 28D "

TENSILE STRENGTH

NEAT				SAND 1-3		
AGE	LBS. PER SQ. INCH	AVG		AGE	LBS. PER SQ. INCH	AVG
24H	321			24H		
	300					
	390	337				
7D	800			7D	356	
	840				375	
	842	827			361	364
28D	955			28D	450	
	970				470	
	953	959			460	460
3 MO	984			3 MO	467	
	998				482	
		990				474

to prevent rusting-through or collapsing, and cement was tried instead of seed-bags or trusting to the formation itself.

After several years use for shutting off water, either above or below the oil-sand, cement is now recognized as being the only consistently successful material for the purpose. The cement manufacturers have made exhaustive tests in order to produce a cement that meets all requirements for this class of work, the well shown in log No. 1. This well, when first pumped, produced nothing but salt water. Tests were made and the water located in the lower portions of the sand. The well was then plugged at the bottom with 2½ tons of cement, which, after setting, was found to have filled the hole from 700 ft. back to 650 ft. Pumping was resumed, and the well now makes an average of 150 bbl. of oil per day with a negligible percentage of water. The same method was followed

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in the well shown in log No. 2, and the water excluded. In log No. 3, the well was drilled to the oil-sand without shutting off the water, for the reason that the position of the water-sand could not be definitely determined. The hole was then filled with a tight plug of crushed rock, 1½-in. mesh, back to 2010 ft. and 5 tons of cement was pumped in at that point. The well was subsequently bailed dry of water and has pumped nothing but oil since. These three wells were cemented by me, and are mentioned as authentic cases in order to illustrate extreme conditions and their solution.

In using cement for shutting off water, it should be borne in mind that the cement should have every opportunity to set, and to this end there should be an absence, as far as is possible, of mud, oil, or gas, particularly the last. If gas is left in the hole, it will keep the cement in motion, thereby preventing a proper setting. These materials can usually be removed by pumping in fresh water previous to putting in the cement. The walls should be underreamed for a distance of 75 or 100 ft. above bottom, in order that there may be as thick a column of cement as possible around the casing. Further, the cement should be thoroughly mixed without sand or other materials, and just thin enough to be pumped to its resting place without difficulty well within the time of initial setting, which is from 1 to 2½ hours for the cements used in California. Washing the cement should be avoided. The actual work itself is a comparatively simple process, but experience and care are necessary to insure the best results. In most instances the casing to be cemented will have been carried through several hundred feet of formation, and it is often difficult to keep the hole free from caving for a long enough period to perform the work. Again, as was pointed out above, the cement should have every chance to make a good set, and experience is necessary in order to judge when conditions are favorable; in fact, the personal equation is an important factor. It is too often the case, when a cemented well shows water, for the failure to be charged to the cement rather than to the methods employed by the person doing the work. The greater percentage of failures is due to the fact that many superintendents do not realize the importance of having the well in proper shape for cementing, as outlined above. There are few cements in California which cannot be successfully used if conditions in the well are right.

The two following methods of cementing, in my opinion, meet all requirements and give the most nearly uniform results: 1. By the use of tubing, through which the cement is pumped to the bottom. 2. By pumping the cement into the casing with disc packers above and below the cement in order to protect it from the water in its passage down the casing. This latter method is especially adapted to rotary holes where the casing must be moved at short intervals to keep it from sticking or 'freezing,' as it is is called, and also in deep holes of 3000 ft. or more, where the use of tubing makes the operation long and somewhat dangerous, by reason of the long string of tubing to be handled. Other than the above, I favor method 1, and will cite a typical example. Suppose that the 8-in. casing has been carried to 2000 ft., and 500 ft. below the 10-in. casing where it is to be cemented. A good landing place has been provided and the hole cleaned of cavings. The 8-in. casing is suspended 2 ft. above the landing point and a 3-in. tubing run

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to within 2 or 3 ft. of the shoe or bottom of the 8-in. casing. Fig. 1 illustrates position of each, as well as the packing head at the floor. This head prevents the water from circulating

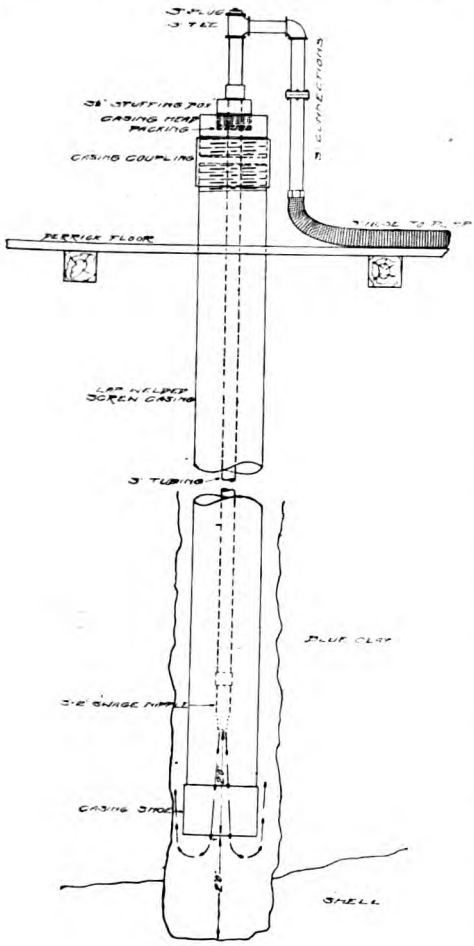

FIG. 1.

around the tubing and up the 8-in. casing, and thus forces the water behind the 8-in. casing and into the space between it and the walls. Fig. 2 shows the arrangement of the cement-pump, mixing box, tanks, etc. The pump should be a duplex, steam, piston-type capable of producing a pressure of 450 to 500 lb. and should have a 5 or 6-in. suction and a 3-in. discharge. The mixing box should be 10 by 20 by 2 ft., which will hold 5 tons of cement. The large tank should have a capacity of 4500 gal. The small tank receives the mixed cement from the mixing box and has a capacity of 100 gal. A screen is placed over the top of this tank to prevent lumps of cement or débris of any kind from getting into the suction of the pump. The 3-in. discharge line, 30 ft. of which is heavy wire-bound hose, connects the pump and tubing. Circulation is obtained by pumping fresh water into the tubing and back of the casing. If the hole is free from mud or cavings, this should be accomplished with a pump pressure of not more than 100 to 150 lb., but should the walls of the hole be caving, it is often necessary to pull back the casing 25 or 30 ft., or more, until the water circulates, when the pressure will fall to normal. The casing is then lowered to its original position. Under ideal conditions, the water, after being started into the hole, will siphon through the pump from the tanks. When water is being circulated in the well, the water may or may not rise to the surface between the 8 and 10-in. casings, according to whether or not a porous sand may be present below the 10-in. casing to receive the water. In most cases half an hour should be sufficient time to judge this and to determine whether the water is actually circulating. It is not well to circulate too long, for in this case the walls might start to caving and stick the casing. The cement, say 5 tons, has been previously dumped through a ½-in. mesh screen into the mixing box, and when the circulation of the well has been accomplished, the 2-in. valve at B is opened and the 3-in. valve at A is closed sufficiently to allow a small supply of water to maintain circulation. Connected to the valve B is 50 ft. of 1-in. heavy-pressure hose with a ¼-in. nozzle.

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The pump is speeded up, if necessary, until the pressure gauge registers 100 lb., when the mixing of the cement begins. Six or eight men stir the cement with hoes, while the heavy pressure in the ¼-in. nozzle aids in getting the mixture uniform and hastens the process. This part of the operation should not consume over 10 or 15 minutes.

The mixed cement is then run into the small tank, T, from which it is taken by the pump and forced down the tubing. This accomplished, the 3-in. plug

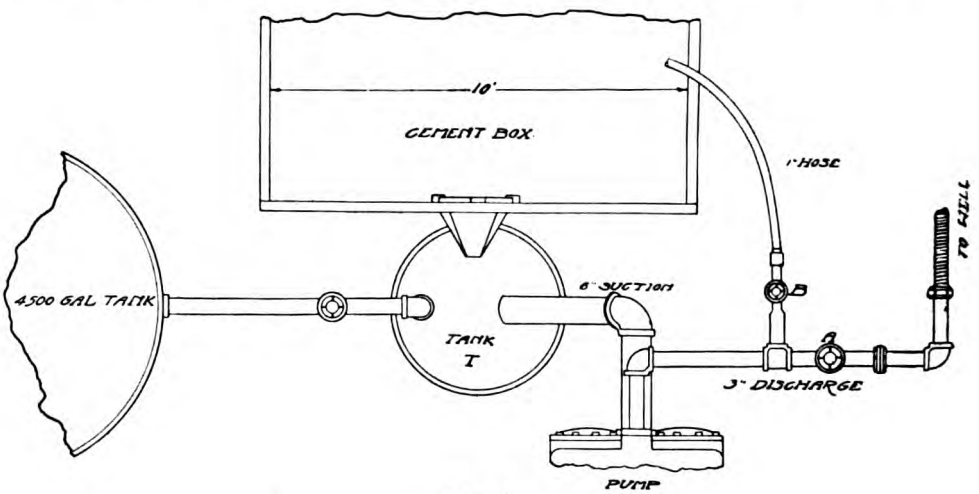

FIG. 2.

in the tee is removed and a redwood plug about 3 ft. long, and tapered at the lower end, is dropped into the tubing. This plug is slightly smaller than the tubing and is forced down, above the cement, until it makes a tight joint in the swaged nipple, which at once causes the pressure on the gauge to rise and indicates that all the cement is out of the tubing. The 8-in. casing is at once set on bottom. The time required between the first application of water to the cement until the casing is lowered to bottom should not exceed 35 minutes if everything works smoothly. The 3-in. tubing is then removed from the well and the bailer run in to ascertain the amount of cement left inside the casing; 2 or 3 ft. is usually found and bailed out at once. The well is then left to stand for at least seven days. Then the 6-in. casing is lowered inside of the 8-in. and the hole drilled 10 or 15 ft. past the bottom of the latter. The water is then bailed to bottom, and the well left to stand for a period of 36 to 48 hours, after which drilling ahead proceeds.

In cementing off bottom-water, the same equipment as the above is used, with the exception of the packing head, which is not necessary. The casing is pulled back, before beginning operations, to a point above which the cement will not rise, and the 3-in. tubing circulated to bottom, the well having been previously cleaned out. Fresh water should be pumped in until the hole is free from gas or sand, after the mixed cement follows. The tubing is then withdrawn and the well left to stand for a week or more. In many cases, the amount of cement to be mixed cannot be determined, owing to the cavities made in the sand by bailing, cleaning out, etc. However, a ton or so may be pumped in at a time and the operation

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repeated until the water is shut out. This is the safest way to avoid cementing off the oil-bearing strata.

The discs mentioned in method 2 are patented packers, made either of cast iron or wood. The lower disc is about 2½ ft. long and has heavy canvas washers which expand to the casing and form a tight joint on their passage down the casing. The upper disc, about 2 ft. long, has a washer below, while above is a leather cup which prevents any water from going past the packer. Circulation is first obtained, after which about 200 cu. ft. of fresh water is pumped into the hole, provided a rotary has been used. The lower pack is then placed inside the casing and the mixed cement follows. The upper packer is next put into the casing and the cement forced down with water between the two packers. When the lower packer reaches bottom, the cement passes it and goes behind the casing. The upper packer then lands upon the lower packer when the pump pressure goes up, indicating that the cement is behind the pipe. The casing is then set on bottom, and after a week or so the packers are drilled out and the well bailed down. These packers cannot be used in cementing off bottom-water, as it is necessary to have the casing as a guide to the point to be cemented.

If water is encountered several feet below the oil-bearing strata and a solid formation such as a shell or hard shale is found between the two, it is often possible to drive crushed rock into the hole above the water-sand and thus form a tight plug. A few sacks of cement should be added to make the plug solid. After having pumped or bailed the well long enough to be sure of its making water, steps should be taken at once to protect the oil-sands. If wells are left with the water running in, long and costly operation is often necessary before it may be finally excluded. Wells pumping water for any length of time are always difficult to cement, by reason of the cavities made in the sands, and the fact that the water is attracted toward the hole and cuts underground channels to it. If for any reason, it is found impossible to shut out the water, the well should be plugged with cement and abandoned. Had the above precautions been observed, many of our oilfields would be free from water today and the need for legislation would not have arisen.

The Stationary Diesel Engine

By HERBERT HAAS*

AT a general meeting of the National Society of German Engineers in June 1897, Rudolph Diesel, the well known German engineer and inventor of the Diesel engine, reported exhaustively on what may be considered the first practical success with his engine on a large scale, and discussed its thermo-dynamic working process and theory.[1] Mr. Diesel pat-

*Consulting Engineer, Merchants Exchange Bdg., San Francisco.

[1]R. Diesel, *Diesels rationeller Wärmemotor*, Zeitschrift d. Vereines deutscher Ingenieure, July 10 and 17, 1897.

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ented his epoch-making invention in all civilized countries in 1892, and in 1893 published his classical treatise on the 'Theory and Construction of a Rational Heat Engine to Replace the Steam Engine and Internal Combustion Engines of Today.'[2] Since then, the development of the Diesel engine has been rapid, and with about one million horse-power of Diesel engines in operation in all parts of the world, it cannot be stated that his engine is still in the experimental stage.[3]

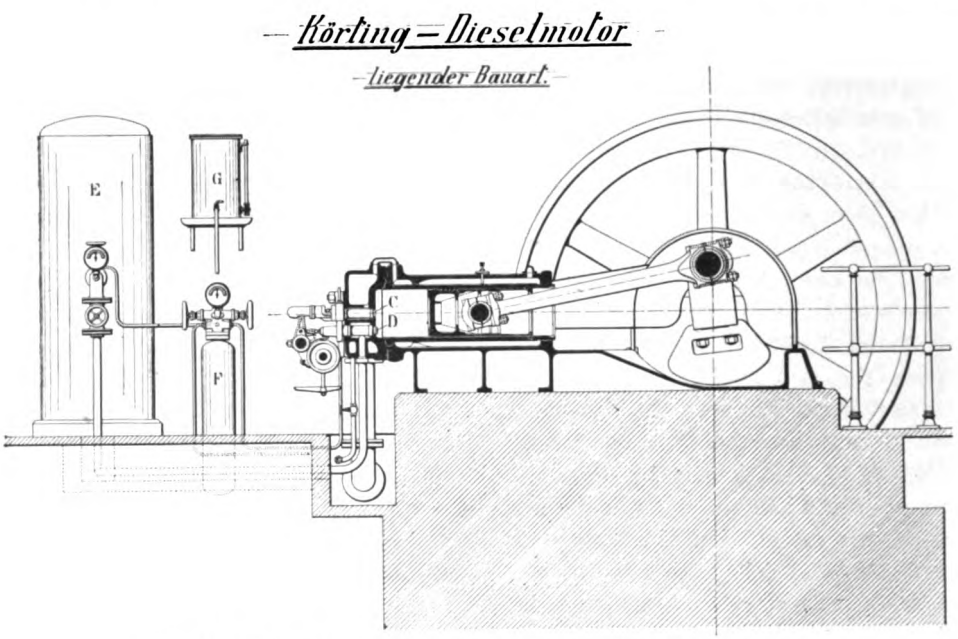

FIG. 1. SECTIONAL ELEVATION OF DIESEL ENGINE AND ACCESSORIES.

Of the salient features which have brought about the rapid adoption of the Diesel engine, its unsurpassed fuel economy is undoubtedly the most important. While the best modern steam plants convert, under the most favorable conditions, only 11 to 14% of the fuel consumed under the boilers into effective work, the Diesel engine has an average thermo-dynamic efficiency of 33%, that is, the Diesel engine will develop the same amount of power with one-third to two-fifths the amount of fuel oil required by the most modern steam-power plants. In small steam plants, with simple engines operating non-condensing, the average efficiency is about 4% and with compound condensing engines about 6%. Steam consumption is an index only of the quality of the design, construction, and operation of the steam engine; the steam consumption guarantees cannot be used as a means of comparing the relative economy of a steam-power plant and a Diesel engine power plant. A comparison must be on the basis of a complete steam-power plant and its fuel consumption per power unit delivered,

[2]R. Diesel, *Theorie und Konstruktion eines rationellen Wärmemotors zum Ersatz der Dampfmaschinen und der heute bekannten Verbrennungsmotoren*, Berlin, 1893, Julius Springer.

[3]A. Naegel, *Die neuere Entwicklung der ortfesten Oelmaschine*, Z. d. V. d. I., Vol. 55, August 12, 1911.

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which must include heat losses and power required for the auxiliaries, that is, boilers, boiler feed-water, vacuum and circulating pumps, as well as the large heat losses in condensing. Comparison of operating and maintenance expense should also be made on the basis of such charges for a complete steam-power plant with those of a complete Diesel engine power plant.

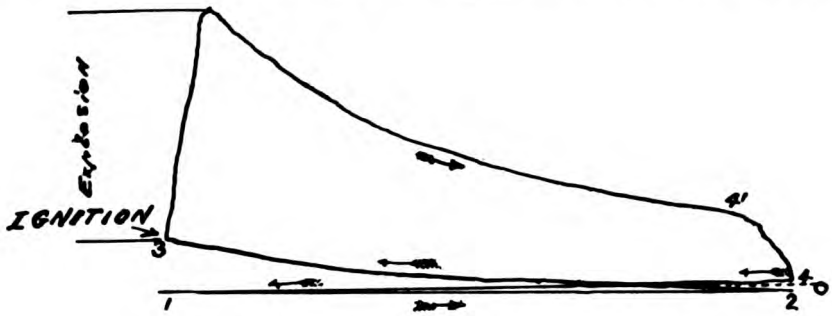

FIG. 2. INDICATOR CARD, OTTO CYCLE ENGINE.

A remarkable characteristic of the Diesel engine is that its fuel consumption in actual operation rarely exceeds the guaranteed fuel consumption secured under test conditions. This high efficiency is secured independent of the skill of the engine runner. The steam-power engineer has to keep proper draft conditions under his boilers, maintain a high vacuum, control the temperature of the circulating water, and keep not only the prime mover at highest efficiency, but all the auxiliary equipment as well, whereas the high economy of the Diesel engine is chiefly the result of the automatic operating features. One characteristic is the 'flat' fuel consumption curve, that is, the fuel consumption increases but little with fractional loads, which fact is chiefly responsible for the above named favorable conditions. Thus while the net thermo-dynamic efficiency is 35% at full load, it is 33% at 75% load, and 28% at 50% load. Equally important is that fuel consumption ceases with the stopping of the engine. Thus stand-by losses, and losses from operating under fractional loads, which aggregate a large proportion of the heat in a steam-power plant as well as suction gas-engine power plants, are practically eliminated in the Diesel engine. It is particularly adapted for a stand-by or reserve engine, as it can be started to full load in two or three minutes.

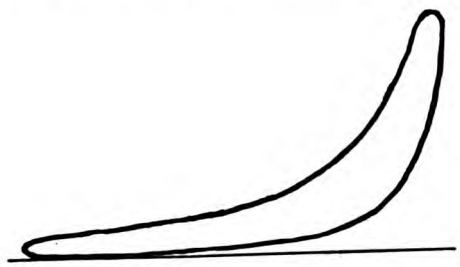

FIG. 3. INDICATOR CARD, DIESEL ENGINE.

As the economy of the smallest Diesel engine is nearly as high as that of the larger engines, electric light plants and other power plants in which the load varies between wide limits during continuous operation, can install two or more units, of which one or more units can be shut down during periods of continuous low loads, while the remaining units are operated at full or nearly full load, and thus obtain a marked saving in fuel, as well as main-

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tenance and operating charges. This practice has the further advantage of maintaining the continuous efficiency of the engines, as they may be operated in succession.

On account of its high fuel economy and constant readiness for operation, the Diesel engine is ideal for the decentralized or isolated power plant. Owing to the large initial investment required for hydro-electric power plants, coupled with the up-keep expense of high tension transmission and distributing systems and the large losses in transmission, with the added expense of maintaining and insuring continuity of service by operating large steam power plants as reserve or stand-by plants, interest charges form a large part of the operating expense in such systems, which are only profitable with favorable load factors and an extensive market for their power output insured for long periods of time.

For this reason, decentralized Diesel engine power plants, with the direct and immediate application of their power or the transmission of their electrical energy limited to serve a comparatively small area will have a materially lower cost, which feature, coupled with the high efficiency of even the smallest plant, will give Diesel engine plants a great field of usefulness in the economical application of power.[4]

Working Process

The Diesel engine works on the constant pressure cycle. Use is made of a well known physical property of air. When compressed, air becomes heated. The compression in the Diesel engine cylinder is carried to such a point that a high temperature, 1000°F. and higher, is imparted to the air and into this 'red hot' atmosphere, the liquid fuel such as crude oil, residue, tar oil, vegetable or animal oils, is injected under still higher pressure. The heated air causes the ignition of the injected fuel without explosion. The burning process being gradual, the ignition is accomplished without any external means, such as electrical or other sparking devices, hot balls, or hot tubes. For the sake of simplicity the four-cycle engine is here described, instead of the two-cycle.

Fig. 1 shows a Diesel engine installation in elevation. This engine works on the four-cycle principle, that is, the engine receives a working impulse with every alternate revolution. On the outward or intake stroke, fresh air is admitted through the mechanically controlled air inlet valve. On the inward, or return stroke, this air is compressed to about 450 to 500 lb. per square inch and becomes highly heated. A few degrees before the completion of this compression stroke, the liquid fuel is injected into the engine cylinder through the fuel-oil injection valve and atomizer C, by means of highly compressed 'injection' air furnished by an independent high-pressure compressor and stored in the injection air-bottle F from which it is supplied to the fuel-oil injection valve C. This high-pressure injection air atomizes the oil completely, breaking it into a fog-like mist which, on being mixed with the 'red-hot' atmosphere of the engine cylinder, is burned and gasified. The gases on forcing the piston forward, expand gradually, very much as steam would expand after its admission into the cylinder has been cut off.

On the discharge stroke, or the fourth cycle, the burnt gases are expelled

[4]R. Diesel, *Ueberlick über den heutigen Stand des Dieselmotorbaues und die Versorgung mit flussigen Brennstoffen*, Z. d. V. d. I., Vol. 55, Aug. 12, 1911.

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through a discharge or outlet valve into an exhaust tank and through an exhaust silencer into the atmosphere. The piston sweeps all gases before it and acts as an efficient 'scavenger.' The action of the engine as a scavenging pump during the fourth cycle is important, in that the air taken in on the next stroke (first cycle), beginning the repetition of the above cycles, will not become mixed with any of the products of combustion, which would not only decrease the efficiency of the engine, but might cause what is known as pre-ignition, if any incompletely burned gases should be present.

The injection air furnished by the compressor is stored in the injection-air bottle *F* at a pressure of about 900 lb. per square inch, at which pressure the fuel oil is injected into the engine cylinder. A portion of this injection-air is diverted from the injection-air bottle *F* to the air-receiver *E*, in which it is kept at about 220 lb. pressure. For starting the engine, air from the air-receiver *E* is used, this receiver having a direct pipe-connection with the starting valve *D*, situated below the fuel-oil injection valve. It is mechanically operated through the same cam-shaft that controls and operates the air-inlet and exhaust valves. The valve is provided with a spring and unloading plunger, and admits compressed air during the starting of the engine only as long as the pressure in the engine cylinder is lower than that of the compressed air used for starting. To permit the use of compressed air at a lower pressure (110 lb. instead of 220 lb. per square inch) for starting the engine, the compressed air produced in the engine cylinder while starting is automatically released through the exhaust valve by means of an auxiliary cam. After the engine is speeded up, and the pressure in the cylinder is greater than that of the air used for starting, then the cam-shaft with cam that operates the starting-valve *D* and the auxiliary cam that engages the exhaust valve are shifted; the starting-valve *D* is thrown out of action and all of the valves used while the engine is running, come into action in their regular sequence. This makes a small volume of low-pressure air sufficient to start the engine. As soon as the engine is running 'under oil,' the throttle valves on the compressor are opened full, and a portion of the air delivered to the injection-air bottle *F* is diverted to the air-receiver *E*, which is refilled with air, the compressor being of a capacity to refill the receiver *E* in 15 to 20 minutes. Whenever a portion of the air in the air-receiver *E* has been used for starting purposes the air-receiver should be refilled as soon as the engine is in regular operation.

G is the day's supply-tank of fuel oil, from which the fuel oil flows by gravity to the fuel pump of the engine. This tank is supplied with a filter on which any sand, grit, or foreign matter in the oil is collected. It is refilled daily with fuel oil from the main oil-storage tank by means of a hand or power pump. The injection-air bottle *F* is supplied, charged with highly compressed air, as a portion of the engine equipment, and this air is used to start the engine for the first time after its installation. After the engine has once been placed in operation, this injection-air is furnished from the direct-connected compressor, which thereafter supplies the required air for injecting the fuel oil as well as for starting the engine.[5]

[5] E. Koerting, *Ueber Dieselmotoren*, Wochenschrift d. Verbandes technischwissenschaftlicher Vereine, No. 6, 1911.

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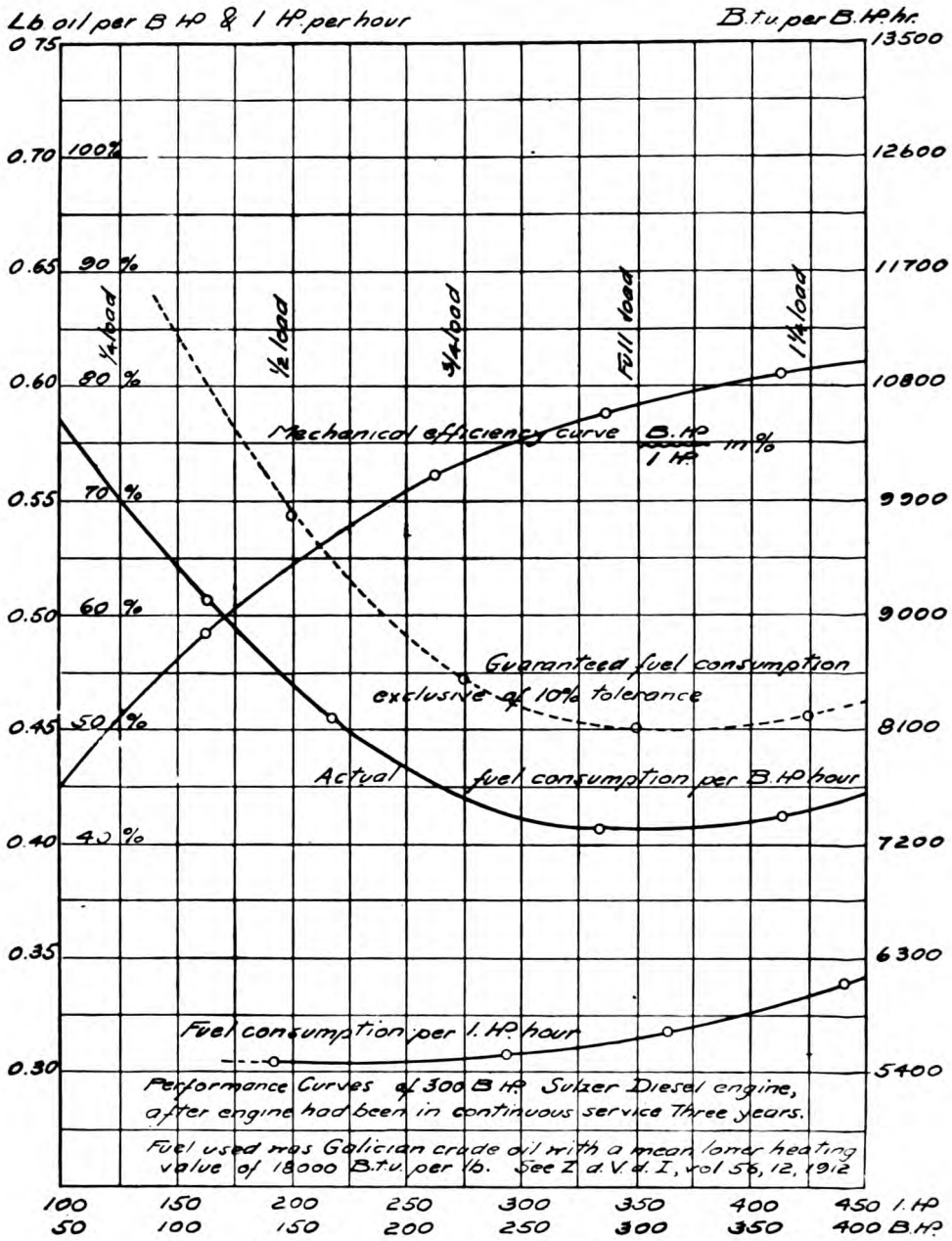

J. Cochand and M. Hottinger, *Versuche a n einer Sulzerschen 300 pferdigen Dieselmotorenanlage mit Abwaermeverwertung*, Z. d. V. d. I, Vol. 56, March 23, 1912.

A study of the working process makes apparent the necessity of high-compression in the engine cylinder. Of equal importance is the complete atomizing of the fuel oil, for which highly compressed air of 850 to 900 lb. pressure is required. Both are necessary for securing a high thermal efficiency as well as to make it possible to burn heavy fuel oils and residues, coal tar,

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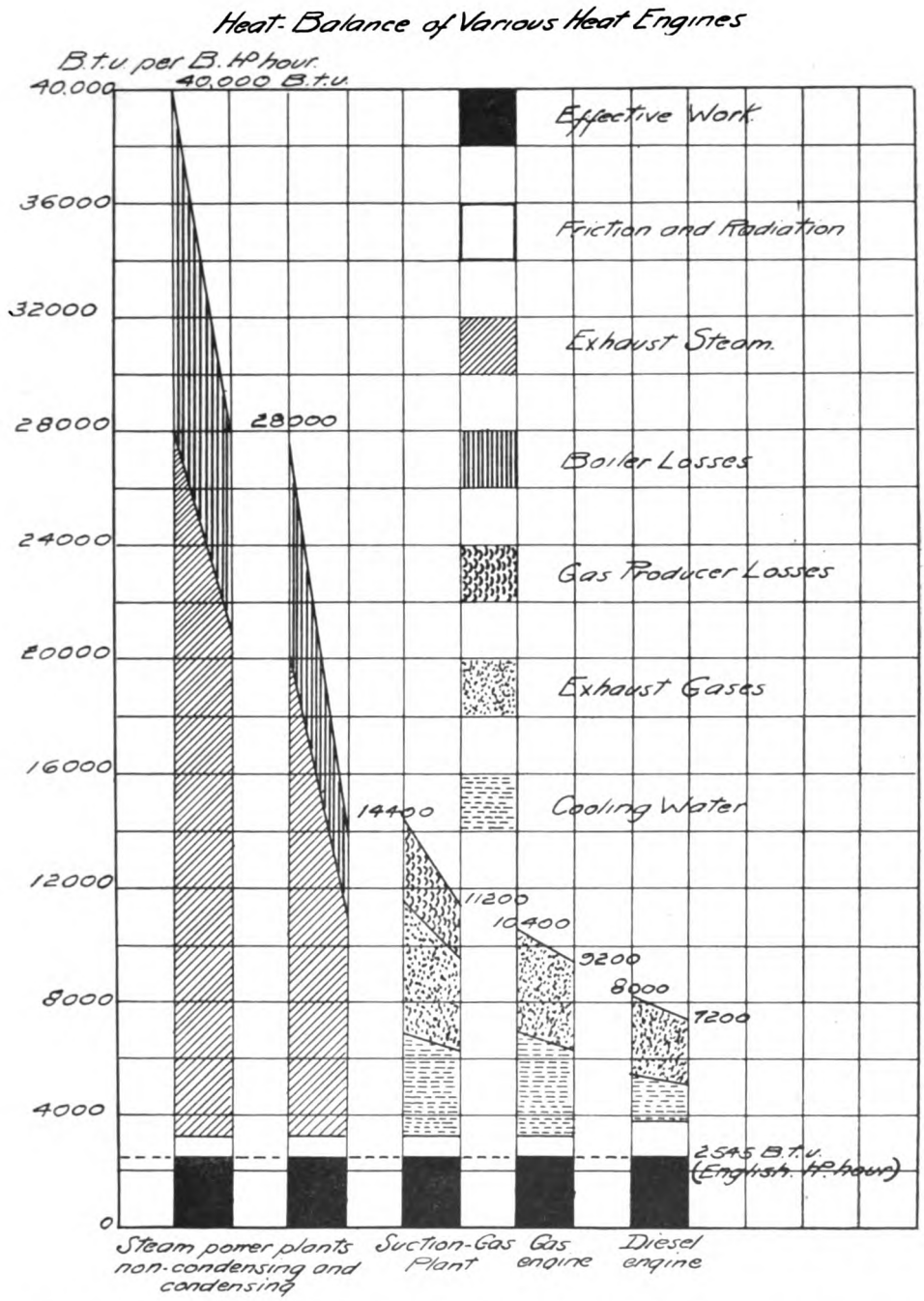

F. Barth, *Die Wahl einer Betriebskraft*, Z. d. V. d. I., Vol. 56, No. 40, 41, 42, Oct. 1912.

tar oils, and asphalt base oils, and to burn them in the very short time available for this process.

The heated oxygen in the air greatly accelerates burning, rendering it so intense and complete as to leave no re-

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sidual constituents unconsumed in the engine cylinder, thus preventing its rapid carbonization.

The exhaust is colorless and odorless, the engine also fulfilling all hygienic requirements. The highly compressed injection-air is necessary for injecting the fuel oil into the engine cylinder and for breaking the heavy oils into a fog-like mist so that it is rapidly mixed with the 'red hot' atmosphere in the engine cylinder, burned, and converted into gas. As all the oil injected into the engine cylinder should be completely consumed and burned before the piston has been forced forward more than 20° or one-ninth of a complete working stroke, the oil must be burned in the short time of one-forty-fifth of a second in an engine running at the moderate speed of 150 r.p.m. In an engine running at the high speed of 300 r.p.m. the time allotted for burning this oil becomes one-ninetieth of a second.

In order to get a fair idea of the rapidity and intensity of the burning process, consider that about one-third of the amount of fuel burned under a boiler supplying steam for a 1000-hp. steam-engine is burned in the small cylinder of an oil-engine of equal horse-power and that the cylinder space in which this combustion takes place is only about 1/200 of the grate area required for the boiler, also that the time for burning the oil is usually less than 1/10 of the total time needed by the piston to travel forward one complete stroke. Mr. Junkers has figured that in the oil-engine the heat from the burning oil is generated at the rate of about 75,000 B.t.u. per hour per square foot, whereas in the steam boiler this heat transmission is only at the rate of 11,500 B.t.u.[6] per hour per square foot.

In this connection, it is well to compare the essential difference between the ordinary petroleum, gasoline, or distillate engine, making use of the so-called Otto cycle, with the Diesel engine. In the former, very light oils, distillates of the crude oils, are broken up into a spray and mixed with heated air in a chamber which is known as a 'vaporizer' and which is connected with and forms part of the combustion chamber or working cylinder of the engine. This inflammable and explosive mixture of petroleum vapor and air is drawn into the engine cylinder, whereas in the Diesel engine pure air is admitted for the same corresponding cycle. The compression of this inflammable and explosive mixture on the return stroke or second cycle must be kept very low to prevent the mixture from being heated to a point at which pre-ignition, which is highly objectionable, would result. This compressed mixture of petroleum and air is ignited by a sparking device of one form or another just before the completion of the compression stroke. There is a resulting explosion. The pressure rises rapidly and then falls off gradually as the gases expand. Any missed ignition results in the discharge of the unburned gas mixture which should have produced a working impulse, and the fuel is wasted. Missed ignition, as well as low compression, result in unburned or incompletely burned gases, which, discharging into the exhaust, are likely to be fired by the exhaust product from the following charges, producing explosions in the exhaust pipes. All these irregular explosions are highly objectionable, give constant shocks to the engine, and seriously interfere with the

[6]Prof. Junkers, *Kritische Betrachtungen zur Konstruktion von Grossoelmaschinen*, Z. d. V. d. I., Vol. 56, Dec. 21, 1912.

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regular running of the engine.[7]

It has long been a recognized fact that the economy of the internal-combustion engine increases with the compression. In all internal-combustion engines, where a mixture of inflammable gas and air is compressed, this compression is limited in order to prevent preignition.

In the Diesel engine, all these objectionable features have been overcome and today it is the heat engine approaching more nearly ideal conditions than any other engine. Taking pure air into the cylinder instead of an explosive mixture of air and petroleum vapor, the air can be compressed to a high pressure (as it contains no inflammable gases), thereby heating it to a high temperature. This highly heated air furnishes the means of igniting the heavy oil, when it is injected, as well as the oxygen required to burn it, and insures automatic, unfailing ignition, without mechanical igniters, electric or other sparking devices, thus eliminating missed ignitions so common in distillate and gasoline engines.

The difference between the Otto and Diesel cycles is illustrated in the indicator cards, Fig. 2 and 3. This difference is further reflected in the amount of fuel used by the Diesel engine and by distillate and gasoline engines under average operating conditions. Thus the Diesel engine uses about half as much fuel as distillate and gasoline engines to develop the same power, but distillate being about 5 times and gasoline about 10 times more expensive than the crude fuel oils or residues burned by the Diesel engine, its fuel economy is 10 to 20 times greater than that of distillate or gasoline engines.

Available Fuels

The fuels available for use in the Diesel engine can be classified as follows:

1. The natural crude oils and their distillates and residues, regardless of whether they have asphalt or paraffin bases. These constitute the chief and most important fuels of the Diesel engine.

2. Oils derived from bituminous slates, known as 'slate' oils.

3. Derivatives from the distillation of lignites, chiefly 'paraffin' oils.

4. Derivatives from distillation of bituminous coals, chiefly tar oils (creosote oil, anthracene oil, benzol, etc.), and coal tars.

5. Vegetable oils, like earthnut oil, ricinus oils, and similar oils.

6. Animal oils, like fish oils, etc.

7. Artificial hydro-carbons prepared from plants, as alcohols, etc.[8]

Of the last three classes of fuel oils for the Diesel engine, the earthnut oil may attain some importance in future in tropical countries where no other fuels, except wood, are available, as in these countries the earthnut grows in such profusion that it will furnish an inexhaustible and cheap supply of fuel oil for the Diesel engine. At present, tar oils, coal tars, and the natural crude oils and their residues are the principal and most important fuels of the Diesel engine.

I wish to emphasize here that asphalt base oils are not objectionable for use in the Diesel engine, and oils containing as much as 50% asphaltum are suc-

[7] W. Robinson, *Gas and Petroleum Engines*, Vol. I and II. (Spon & Chamberlain, New York.)

[8] R. Diesel, *loc. cit.* [4]; also, *The Diesel Oil Engine, and Its Industrial Importance, Particularly for Great Britain*, a paper read before the Institution of Mechanical Engineers of Great Britain, March 15, 1912. (Published in full in *Journal* of the American Society of Naval Engineers, Vol. XXIV, No. 2, May 1912; abstracted in *Engineering News*, April 4, 1912.)

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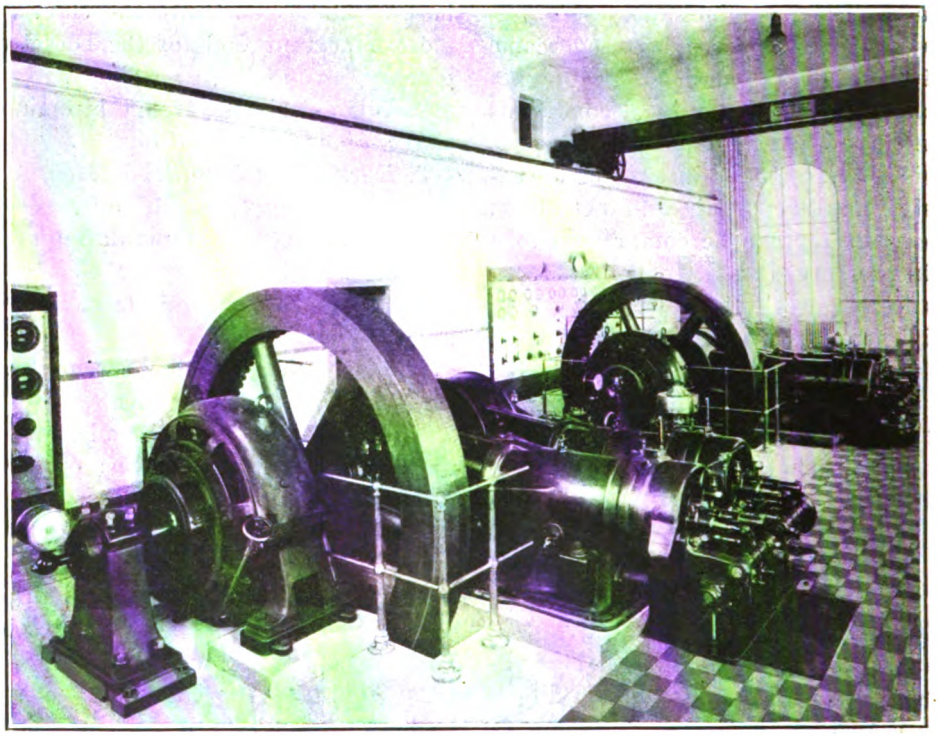
cessfully and constantly being used. As the viscosity of such oils is low and they do not run freely, it is necessary to increase their fluidity by warming them. This is done by starting and running the engine for about 10 minutes with a lighter gravity oil which flows freely to the fuel-oil pump of the engine at the ordinary room temperature. As soon as the engine has been warmed up, a portion of the engine jacket water may be used to warm the heavy asphalt oil or residuum, and as soon as this is liquid enough to flow to the fuel-oil pump, the light oil supply to the pump is shut off and the heavy oil is substituted. If the engine is to be stopped, the light oil should be switched on about ten minutes before stopping the engine, replacing the heavy thick residuum oil.

All that is necessary for the use of such oils is an additional small tank (smaller than the day's fuel oil supply-tank) to store a small amount of light oil for starting purposes with a separate supply pipe-line and valves. Several per cent sulphur in the oil is not objectionable in engines fitted with air-cooled pistons, as the valve and valve-seats may be made of a composition that resists corrosive action of sulphurous acid. Furthermore, parts so exposed are removable and inexpensive to replace.



TWO 300-B-HP. TWIN CYLINDER KOERTING DIESEL ENGINES DIRECT CONNECTED TO D.C. GENERATORS FOR LIGHTING SERVICE.

Fuel Consumption

Burning fuel oil or residue with a mean lower heating value of 18,000 B.t.u. per pound, the Diesel engine, operated at full load, will deliver one brake-horse-power with a consumption

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of fuel oil or residue of 0.40 lb. At ¾ and ½ load, this consumption per brake-horse-power hour will increase but slightly.

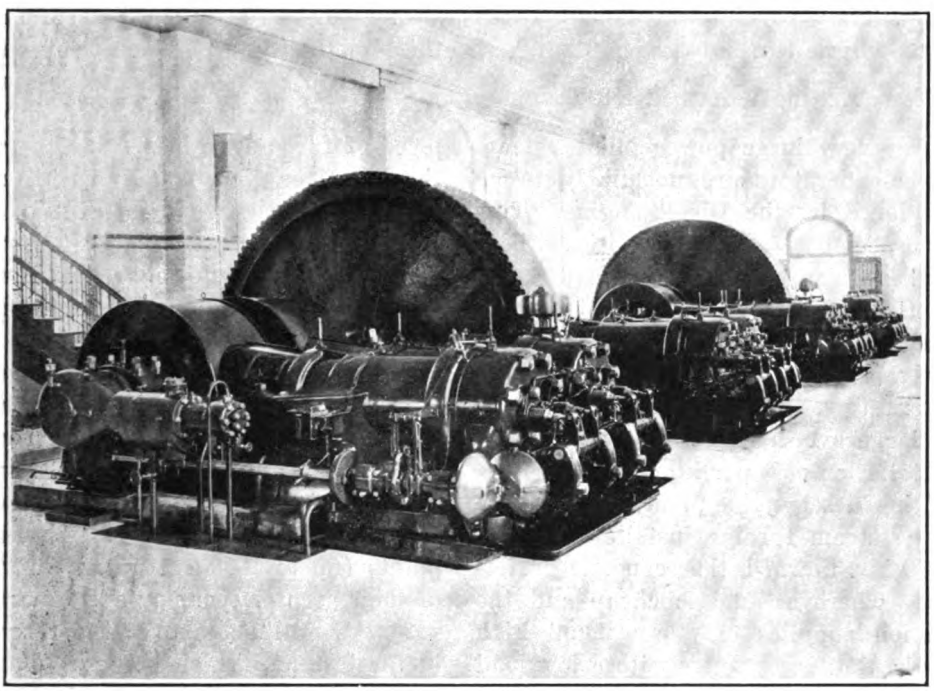
The above consumption refers to the larger engines, but the smaller Diesel engine of 15 b-hp. is nearly as economical as the largest engine, developing a brake-horse-power with less than half a pound of fuel oil. With oil costing $1 per barrel (330 lb.), the Diesel engine will generate a brake-horse-power hour at a fuel expense of less than 0.15 cents.

Jacket Cooling Water

The cooling water required is from 2½ to 4 U. S. gallons per brake-horse-power hour, the volume of circulating water required decreasing with the increase in the size of the engine. Using a cooling tower, one-fifth of the above quantity of the circulating water will suffice for cooling the engine.

Electric Current Generation

The smooth operation and precise and sensitive regulation, and the high fuel economy of the Diesel engine place it at the head of prime-movers for the generation of electric current at low cost. Considering that 500 kw-hr. can be delivered to the switchboard with one barrel of crude oil (6,000,000 B.t.u.) by means of the Diesel-engine driven generator operating at full load, and 450 to 470 kw-hr. at ¾ load, and 400 to 430 kw-hr. at ½ load, this type of engine has a large economic field as a prime-mover, as it will generate electric current at very low cost. Under average Western conditions, with fuel costing $1 per barrel, and in a plant equipped with three 400-kw. Diesel-



TWO 600-H.P. KOERTING DIESEL ENGINES DIRECT CONNECTED TO ALTERNATORS WORKING IN PAIRS AT DESSAU ELECTRIC POWER PLANT.

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engine generator sets working in parallel, a kilowatt-hour can be delivered to the switchboard for 0.45, 0.48, 0.58, and 0.61c., respectively, at 100, 80, 50, and 46% load factor, which costs include labor, fuel, lubrication, repairs, and maintenance. Capital charges (interest and redemption) increase these amounts to 0.645, 0.725, 0.95, and 1.05c. respectively per kilowatt-hour. These costs will be less in a larger plant.

Diesel Engine Versus Steam Turbine

For very large power plants, steam turbo-generators are not likely to be displaced by the Diesel engine. This is especially true in localities where fuel is cheap and when the load factor of the plant is very low. The steam turbine is, on account of its high rotative speed, the ideal prime-mover for alternators. Its great flexibility, due to large over-load capacity, and lower installation cost per kilowatt than that of the Diesel engine plant, will give the large steam turbine installation, from 5000 kw. upward, the economic preference wherever fuel is cheap and the station supplies only occasional high loads, that is, operates with a low load factor. In such cases capital charges are materially less for the turbine installation and offset any saving in fuel possible with the Diesel-engine installation. Frequently, a combination plant, in which the Diesel engine is operated continuously at a favorable load, and the turbine is used to supply the peak loads only, permits of great economy in fuel. The waste gases from the Diesel engine are then passed under the boilers; frequently sufficient gas is supplied to keep them up to pressure.[9] Conversely, with an increase in the price of fuel and a better load factor, the Diesel engine plant gains in economic superiority, and a decision in favor of either a turbine or a Diesel-engine plant should be reached only after careful determination of the unit power cost with each plant.

As units up to 6000 b-hp. (in one engine) are now being built in Germany, the Diesel engine will also be available for the larger central stations. Small Diesel-engine plants will easily have the preference over small steam-turbine plants (up to 1000-kw. units), in view of their greater economy and other advantages outlined above; the remarks in the last paragraph being applicable more to large central power stations.

Tunnel Grouting at Haiwee Reservoir, Los Angeles Aqueduct

By J. B. LIPPINCOTT*

THE Haiwee tunnel is the outlet of the Haiwee reservoir on the Los Angeles aqueduct, and will be subjected to a pressure head of 77 ft. It is proposed ultimately to connect this tunnel with a steel penstock 10,000 ft. long, giving a total head of 192 ft., and obtain the water pressure from the surface of the reservoir for the generation of power. As the tunnel will

*Assistant Chief Engineer, Los Angeles aqueduct.

[9]W. Kaemmerer, *Die Verwendung von Dieselmaschinen zum Antrieb von groesseren Seeschiffen*, Z. d. V. d. I., January 20, Vol. 56, Feb. 24, March 9, March 23, 1912.

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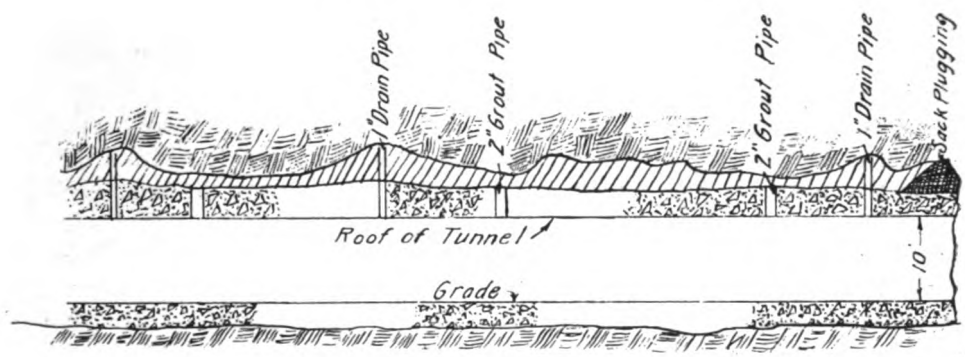
be under 77-ft. head, it is desirable to have a tight bond between the concrete lining and the roof. The grouting process described below is intended to accomplish this purpose. The work has been under the direct charge of A. P. Cox.

The grout-pipes were placed 20 to 28 ft. apart in the concrete lining of the roof. The high drain-pipes were 1 in. diameter, and were set so that the tops were near the top of a cavity, or high point in the roof of the tunnel. The grout-pipe, through which the grout

The Haiwee tunnel is driven in a soft shale and was trimmed true with picks. It has an excavated diameter of 11 ft. 8 in., and a diameter of 10 ft. when concreted. The pump forced the grout between the concrete of the tunnel and the rock. A cement mortar was used, mixed in the proportion of one part of cement to one of sand, with enough water to permit it to flow freely. An average of 2 cu. ft. of grout per lineal foot of tunnel, as measured in the solid aggregates, was thus placed. The concrete lining was put in this tunnel with

TUNNEL GROUTING AT HAIWEE



was forced, was 2 in. diameter. It had a pipe coupling on the lower end with an inside thread to provide for a connection with the force pump. The pump is an Edson No. 8 diaphragm and force pump, frequently used for sewer work, and is driven by hand. It has a 2½-in. suction, a 2-in. discharge, and is operated by two handles working vertically. It cost $115.75 f.o.b. Los Angeles, the price including 10 ft. of suction hose and 50 ft. of conducting hose. The conducting hose was 2-in. inside diameter and made of rubber. The pressures available from the pump are in the neighborhood of 50 lb. The diaphragms are of rubber and can be replaced when worn out by grit.

care, an effort being made to ram it as tight as possible, and the tunnel itself was trimmed very much better than rock tunnels usually are. However, concrete, in taking its set, shrinks slightly and leaves a space, especially along the roof, and, in addition to filling this space the cement grouting was actually forced into the minute laminations of the shale.

The labor required for grouting was 6 men, costing $15 per day, who grouted 45 ft. of tunnel per day, or at the rate of 33c. per foot of tunnel for labor alone. The grout was pumped into the first hole in the tunnel, and the end of the concrete lining near the portal of the tunnel was plugged with

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sacks to keep the grout from flowing out. The grout would flow along the tunnel as much as 60 to 80 ft., and manifest itself through the concrete, seeping through minute cracks and pores. Neat cement would flow farther than mortar. Sometimes the sand in the mortar would settle around the grout pipe and tend to clog the flow. Then less sand would be used in the mix, and an effort was made in this manner to carry a portion of the sand away with a thin mixture of cement and water. The operator had to study these conditions continually and adjust the mix to suit. The grout was pumped in at the first hole next to the portal, to close the opening between the concrete and the rock at the end of the tunnel. Then the operator skipped the next hole and went to the third to do the next pumping, in order to get a tight ring around the tunnel against which the grout in the intermediate hole could be forced, otherwise the grout had a tendency to run rather indefinitely along the tunnel lining. The best results were obtained when the grout was being pumped into a confined space. The 1-in. drain pipe, which was set into the higher cavities of the tunnel, and perhaps 2 or 3 ft. away from the grout pipe, acted as an air-vent and overflow pipe. When the far end of the tunnel was reached, another sack plug was put in and the grout forced into a grout-pipe 10 ft. back from it. After the pumping was completed, the grout and drain pipes were plugged with mortar. On removing the sack-plugging and examining the grout, the bond between the concrete and the rock was found to be very tight, the grout having been forced into the crevices of the rock, and between the concrete and the roof of the tunnel. No open space was visible.

Another pressure tunnel is now being grouted on the aqueduct, with an ordinary triplex water pump, working up to pressures of 200 lb., with a thin mortar of neat cement, the same piping arrangements for the grout being used. These tunnels have not yet been subjected to internal water pressures, but the present indications are that the work is satisfactory.

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The Engineering Digest

Refining Petroleum Crude Oils*

By J. C. HOWARD

WHILE Colonel Drake's well, drilled on Oil creek, Venago county, Pennsylvania, in 1859, really marked the beginning of the present petroleum age, and was the first oil well ever drilled, still we read of bitumen being used to cement the alabaster bricks together in building Nineveh and Babylon, of it being used as an illuminant by the Chinese, centuries before Christ. The Egyptians used it for embalming; the Romans and Greeks for building and paving; the French of the sixteenth century used it for medical purposes.

The shale oil industry of the British Isles grew to rather large proportions in the early part of the nineteenth century. Miners digging coal in England saw oil trickling down the coal, and to this day a great percentage of the people refer to kerosene as 'coal' oil.

Shale oil was obtained by digging the oil-bearing shale rock, putting it in closed ovens, and catching the oil that was driven out of the rock by heat. A number of small rock-oil refineries were established in England and also in towns on the Atlantic seaboard before petroleum crude oil had been produced in what we would now call commercial quantities in this country.

Oilfields were rapidly developed in Pennsylvania and large refineries were built. The principal product was kerosene; the gasoline and naphthas were not marketable, and large quantities of gasoline were thrown back into the wells to cut the paraffine from the casing. The wax distillates and residuums were either used for fuel or thrown away. However, methods of extracting the wax by certain processes of refrigeration were devised, and instead of running crudes, by fire heat, down to tar only, steam coils were used in the stills to keep the residuums sweet. This made it possible to produce the highest grade lubricants to meet the urgent needs of railroads, power plants, and factory machinery.

The comparatively recent invention and manufacture of the internal-combustion oil-engine, principally for automobile use, has steadily increased the commercial value of gasoline, which on today's market, at refinery and distributing points, averages 100% higher in price than kerosene. For instance, the tank-wagon price on kerosene in St. Louis is 9c. per gallon; gasoline, 18c. per gallon.

The phenomenal production of petroleum in this country and the modern methods of transporting through large pipe lines, tank cars, and across the seas in tank steamers, has made it possible for large American oil companies to compete successfully in foreign countries. They control 50% of the oil trade in Scandinavia, British Isles, Germany, France, Japan, and China, and 80% in Africa and South America.

There are three grades of crude oil, and in these grades there are very many varieties. The first grade, and most valuable, is the paraffine base found principally in Pennsylvania and adjacent states. However, some crudes in Oklahoma and Wyoming, Colorado, and Utah fields are also paraffine. These, however, are generally considered by oil men as semi-paraffine and asphaltic, running from 32 to 48° Beaumé gravity, but the average Pennsylvania high-grade crude runs about 41 to 43°. There are also several grades of paraffine crudes found in Borneo, which are now being refined there.

The next grade of crude is the asphaltic; it is found principally in California, the

*Abstract from the *Salt Lake Mining Review*, January 30, 1913.

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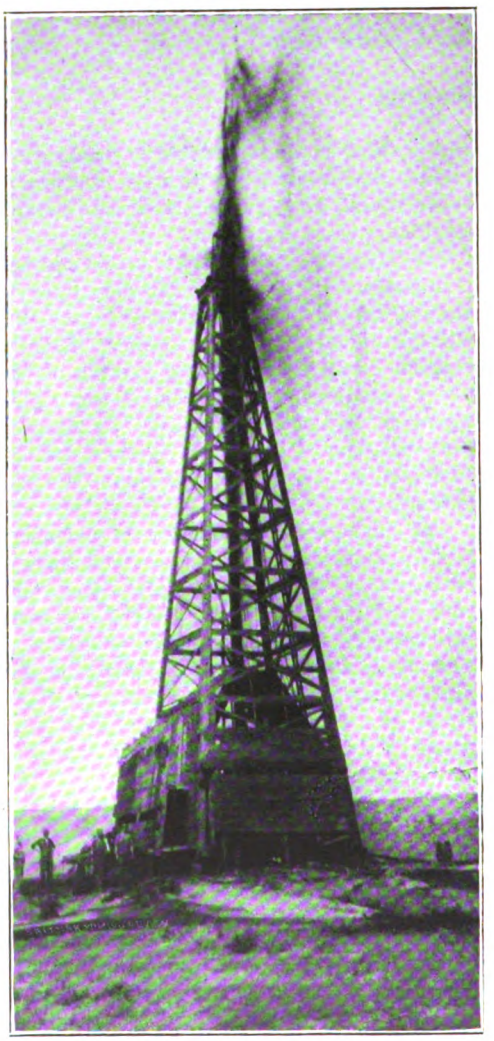
greatest oilfield in the world, producing one-third the world's production, and which amounted to some ninety million barrels during the year 1912. This grade of oil is also found in Texas and Wyoming; which, as a general thing, is not quite as heavy as the asphaltic base crude in California.

There is another grade known as the ole-



GUSHER IN SALT CREEK FIELD, NEAR CASPER, WYOMING.

fine, found principally in the Baku oilfields near the Caspian sea in Russia. This oil has simply a trace of paraffine, but not sufficient to classify it as either. From this crude, very valuable low-cost cold-test lubricants are produced. They have a universal demand for special purposes. Speaking generally, these are the three grades of crude petroleum and from them a great variety of oils can be made.

In 1859 the production in the United States was 2000 bbl. The total number of barrels, containing 42 gal. each, produced in the United States in 1912 reached the grand total of 220,200,000 bbl., or within 200,000 bbl. of the banner year, 1911. The mid-continent and Eastern fields declined about 9,000,000 bbl., whereas California enjoyed an increase of about the same amount. Still, in the face of the 200,000-bbl. decreased production, the total valuation caused by the advanced prices for crude was $16,000,000 more than 1911, or the splendid sum of $150,000,000, which is greater than the combined valuation of all the gold, lead, and silver mined in the United States in 1912.

There were no less than six advances posted on light refining crudes by the big pipe-line companies in 1912. This increase was due, first, to the 10% decline in light crude oil production; second, to the phenomenally increased demands for naphthas, gasolines, and lubricants; and third, by the dissolution of the Standard Oil company of New Jersey as a holding company.

The processes of refining crude petroleum are fundamentally the same today as they were in the old plant of 40 years ago. The most important process in the refining of petroleum today consists essentially of two parts; heating the oil in a still by firing underneath until it vaporizes in the same way as boiling water passes into steam; and condensing these vapors just as steam condenses in contact with colder objects. The successful operation of the different processes depends on the fact that each of the many hydro-carbons composing crude oil has its own particular boiling point, and thus allows gradual heating to carry on the process of division, or fractional distillation, as it is called.

The crude-oil stills, the condensers where the vapors are condensed back into liquid form, the receiving house, where the stillman separates the distillates by weighing their gravities, the receiving tanks, agitators, and storage tanks represent the important parts of the skeleton of every refinery.

The oldest type of distilling tanks used by the early refineries of Pennsylvania was called the 'cheese-box' type, which was higher in step than in diameter. The capacity

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ranged ordinarily around 75 bbl., but larger refineries built them up to 200 and 300-bbl. capacity. Most modern refineries have discarded them and, at the same time, some of the refineries of the present time retain them for special reducing purposes. The cheese-box still, with a capacity, say, of 75 bbl., would not be charged to the full capacity, but only to about 60 bbl. This is to allow the most volatile fractions to rise and ascend over the vapor line and the heavier carbons to return into the still to be re-fractionated. The fire is built with coal or oil, whichever fuel is the cheaper, and steam coils are also put into the still, which are perforated so that live steam can be thrown into the charge; the purpose of this is to keep the residuums sweet, prevent the oil from being scorched, and to assist the fire heat to fractionate the paraffines.

The modern crude still, a horizontal cylinder, was first determined by the Russians in the Baku fields to be more economical. A still having a capacity of 500 bbl. would be about 10½ ft. diameter by 36 ft. in length. As the fire-box is under one end, a great portion of the surface of the still is brought in contact with the live heat, thus obtaining greater efficiency out of the fire than with the cheese-box type. In some of the large modern refineries such as at Point Richmond, California, Bayonne, New Jersey, and Port Arthur, Texas, these stills run from 750 to 1200 bbl. capacity.

Referring to the method of distillation and percentages of various oils obtained from the crude-oil stills, let us take for instance the Casper, Wyoming, crude as a basis from which to illustrate. A 500-bbl. still is charged with 400 bbl. of crude and the fire is built at the direction of the still-man. When the temperature rises to about 160° in the still, the light volatile vapor starts to rise to the vapor lines, then down into the condenser box, and on into the receiving house. By the time it gets into the receiving house it is again condensed into liquid form. This is the beginning of the formation of gasoline distillate; distillate, by the way, meaning no special part of the crude oil, but rather a product of distillation.

As the still-heat continues to rise, the still-man diverts the stream from the receiving house into one large tank, until the gravity in the receiving house is about 51, or until the temperature in the still is about 300; he then diverts the stream into what is known as the kerosene distillate tank. The first cut will yield him about 20%, continuing to run from 51 gravity down to about 38, or about 550°F., into the still. This goes into the kerosene distillate tank, and has an average gravity of about 43. If it were put on the market in this condition, it would be unsatisfactory, making a smoky, sooty flame, and often creating an unpleasant odor. Therefore further treatment is necessary. It is put into an agitator, holding from 100 to 1500 bbl., depending upon the size of the refinery, and treated with sulphuric acid and agitated about thirty minutes. The acid precipitates tarry matter and fixed carbons, and they fall to the bottom and are drawn off. The oil is then neutralized with soda-ash, eliminating all of the acidity, and afterward, it is washed with comparatively warm water, eliminating all acids and foreign substances. From there it is pumped into settling tanks, until all the moisture settles to the bottom. This is generally done by raising the temperature through the use of heating coils. From there it is pumped into the general distributing tank ready for the market. At this point it is cut out, and run, at from about 38 to 35 gravity, or from 576 to 620°, into another receiving tank. This oil is called solar oil or power-distillate, which is now being used very extensively for traction engines and general power service, where continual operation and high temperature are maintained in the engine.

The next cut is in the gas oil from about 620 to about 700°F., or from 35 to 33 gravity Beaumé. At 35 gravity, the still-man diverts the stream into the wax distillate tank, and he runs this down from about 700 to 750° in the still. This last distillate is about 29 to 30 gravity Beaumé, and from it is obtained the wax or paraffine, also the lubricating oils, such as automobile, gas engine, stationary engine, compressor, and other machine and neutral oils.

The residuum remaining in the stills is a finished product as far as distillation is concerned. If this be strictly paraffine oil, then the residuum left in the still is a finished cylinder oil, as far as distilling is concerned, sweet in odor, green in color, say 540° flash, 21-24 gravity, and, after going through processes of treating, filtering, and compounding, is universally used for steam cylinder purposes in steam pumps, stationary steam engines, locomotives, etc. If, on the other hand, it be an asphaltic-base crude, this

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residuum is an asphalt, or bitumen, generally used for a binder in road paving, and runs all the way from 10 to 110 penetration. However, the penetration of asphalt ordinarily used for street paving usually runs from 70 to 80, and the heavier grades are generally used for roofing purposes and for manufacturing waterproof felts. By stopping the still a little sooner, this same asphalt could be used for road-oil or fluxing. For instance, 60 or 70% of this road-oil or flux properly mixed with our Utah gilsonite, makes a highly satisfactory asphalt both for roofing and paving purposes.

A specimen of the binder-course which Mr. Hemen recently put down in one of our Salt Lake City streets, made from this mixture, is thoroughly saturated and is very tenacious and is resilient, which prevents it from cracking in the winter, and from overheating and becoming soft in the summer.

Referring to the condensing phase of refining: from the vapor dome of the still, a vapor line 8, 10, or 12 in. diameter, depending upon the capacity of the still, is attached. This enters a condensing vat made of steel plates, say 20 to 30 ft. in length, 8 to 10 ft. wide, and 8 to 10 ft. high. A series of return coils are put in, commencing with an 8-in., and then reducing to 6, 4, and 3, the 3-in. running into the receiving house. There is a constant stream of cold water being thrown into the condenser from the bottom, and at the top of the condenser there enters a 3-in. overflow pipe, which conducts the hot water out. The larger the still, the larger the condensing box, and the more water it requires for the condensation.

Going back to the gasoline distillate, it might be interesting to know how gasoline is made from this product. If you would place a little of the distillate on a piece of paper you would soon notice the difference between gasoline and this distillate; the gasoline would entirely evaporate, leaving no mark whatever, whereas the distillate would leave a trace of oil, which would not evaporate. This indicates, upon the surface, that in the first distillation in the crude still, the gasoline distillate having been thrown over by live fire heat underneath and live steam in the still, a heavier oil has been fractionated and thrown over with that of more volatile properties. It is, therefore, necessary to take this gasoline distillate and place it in a special still, referred to as a steam still, which is in appearance very similar to the crude-oil still, being a horizontal cylinder ranging from 100 to 1000 bbl. capacity, depending upon the capacity or size of the refinery. However, the still rests near the ground and has no fire-box under it, and the only way it receives heat is through the steam which is conducted by a 2-in. line into the bottom of the still and permits the live, wet steam to enter into the charge through hundreds of small holes in the steam coils lying on the bottom of the still. The distillation of this product should be slow and gradual, and the condensing water extra cold, so that all the vapors may be recovered in the gasoline. If the still is rushed with a full head of steam, then the heavier hydro-carbons come off and it makes a poor quality of gasoline.

The stillman's knowledge and long experience enables him to know exactly what his still is doing, and the quality of the product that he is producing.

Regarding the gravities of gasoline, there is a general tendency to believe that a very high gravity of gasoline is necessary to run an automobile; this is a mistake. It has been proved by government experts, also by numerous automobile manufacturers, that various crudes produce various kinds of gasoline. One crude might produce a large yield of 66 gravity, another crude a large percentage of 63, another of 60. Naturally, the automobile men would say they want the 66, and would most likely pay a premium for it, but it has been proved that the 60 is equal to the 66 in power and response. This is due entirely to the native character of the product and especially to the low distillation point. So gravity is not as serious as some consumers would believe.

Naturally, on account of the tremendous demands on the refineries for gasoline, the gravities have been materially lowered.

It was customary in early days to sell a 78 and then a 72; 66 was considered rather low, but now the great bulk of commercial gasoline in the United States runs between 60 and 61. This is due primarily to the extraordinary demand caused by the universal employment of motor locomotion, and, secondly, through the new crude-oil fields, which produce a lower-gravity gasoline, which, however, as said above, is equally efficient.

Referring again to the use of gas oil: This oil is used principally by gas companies, even if they are running on coal gas, to

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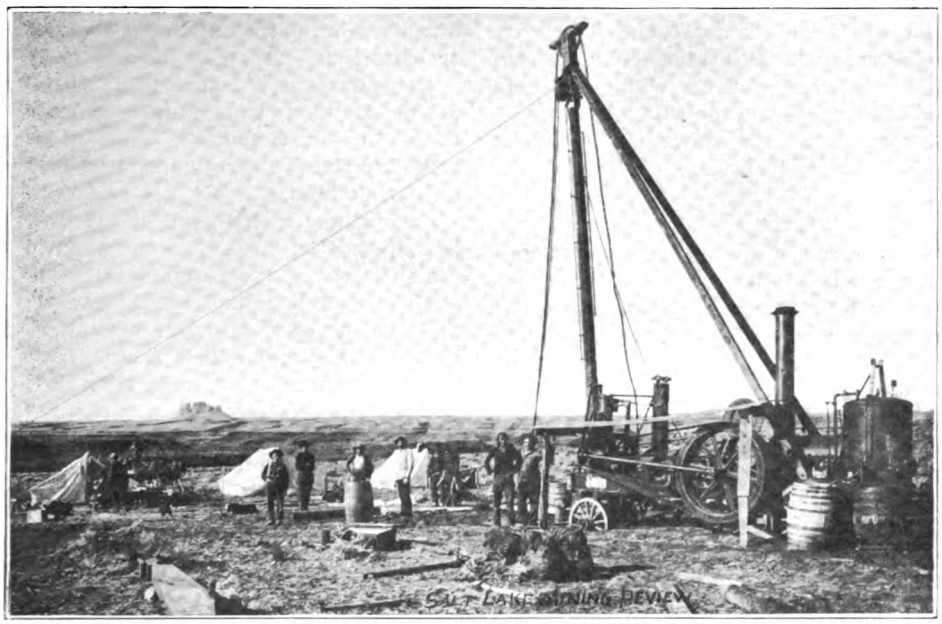
enrich the candle-power of their coal gas and also increase the heat units. For instance, the ordinary coal gas produced by bituminous coal today runs about 14 cp., whereas paraffine will make it 16 to 18 cp. It will also add 200 or 300 heat units per 1000 ft. over and above the bituminous product.

No doubt the wax distillate is the hardest part of the crude oil to handle. This is due entirely to the fact that the paraffines must be extracted before the oils become usable.

In the early days some very crude methods obtained, but at the present the modern refinery of paraffine base crudes has large wax plants, consisting of ice machinery, which reduce the temperature of the distillate to 20 or 10° above zero, and, under pressure, puts it through filter-presses. The plates retain the crystallized wax flakes and the oil is pressed or squeezed out, and drops into a grooved incline leading to the receiving-tank, and is known as pressed distillate.

This wax in the press plates is generally called slop wax; after being thoroughly washed or cleaned by live steam in some outside tank, it is pumped into large sweat-pans, where it is chilled down to a still waxy form, then all the doors and windows are closed, the heat is turned on, and the moisture and oil are melted out; the wax flakes remain on the bottom of the pan, a little more heat is added, sufficient to melt the wax, and it runs into a small receiving-tank, and is then sold for crude scale wax, being packed in barrels and shipped to the various consumers; or, if higher-grade waxes are desired, the refiner makes two or three cuts and after putting it through the filter of fuller's earth, a very fine white wax is produced.

Large quantities of this wax are used for sealing fruit-jars and for ironing, and still larger quantities are used for candles.



STAR RIG DRILLING FOR OIL.

The pressed oil which has been extracted from this wax distillate is put into a small reducing-still of, say, 100 to 500 bbl. capacity, again depending on the size of the refinery, and, on account of its heavy character, must be fractionated by fire underneath and steam coils inside. A great deal of steam is used in the distillation of this pressed distillate, inasmuch as the residuum reduced stock left in the still must be sweet oil, and steam also adds to its viscosity or adhesive nature. This stock is run to 390 or 400 flash, is then either treated or filtered several times, depending entirely upon the purpose for which it is intended, and out of this still stock we get the numerous

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machine and engine oils which are universally used around mills, smelters, railroads, and machinery of every conceivable kind. These oils are generally referred to by refineries as viscous neutrals, and vary in color from a dark cherry-red to almost a prime white. The many products of refining show the development of the industry.

A Proposed Code of Ethics for Engineers

[A committee was appointed by the Council of the American Society of Mechanical Engineers to draft a code of ethics for adoption by the society. In presenting the proposed code, the committee emphasizes the fact that no code can define the duties and obligations of engineers under all possible circumstances and the proposed code merely attempts to cover those relations concerning which questions most frequently arise in engineering practice.—EDITOR.]

GENERAL PRINCIPLES

IT is not assumed that this code shall define in detail the duties and obligations of engineers under all possible circumstances. It is an axiom that engineers in all their professional relations should be governed by principles of honor, honesty, strict fidelity to trusts imposed upon them, and courteous behavior toward all. The following sections are framed to cover situations arising most frequently in engineers' work.

It is the duty of engineers to satisfy themselves to the best of their ability that the enterprises with which they become identified are of legitimate character. If an engineer after becoming associated with an enterprise finds it to be of questionable character, he should sever his connection with it as soon as practicable, avoiding in so doing reflections on his previous associates.

THE ENGINEER'S RELATIONS TO CLIENT OR EMPLOYER

The engineer should consider the protection of a client's or employer's interests his first obligation, and therefore should avoid every act contrary to this duty. If any other consideration, such as professional obligations or restrictions, interfere with his meeting the legitimate expectation of a client or employer, the engineer should so inform him.

An engineer cannot honorably accept compensation, financial or otherwise, from two or more parties having conflicting interests without the consent of all parties. The engineer, in whatever capacity, whether consulting, designing, installing, or operating, must not accept commissions, directly or indirectly, from parties dealing with his client or employer.

An engineer called upon to decide on the use of inventions, apparatus, or anything in which he has a financial interest, should make his status clearly understood by those employing him.

An engineer in independent practice may be employed by more than one party, when the interests of the several parties do not conflict; and it should be understood that he is not expected to devote his entire time to the work of one, but is free to carry out other engagements. A consulting engineer permanently retained by a party, should notify other prospective clients of this affiliation before entering into relations with them, if, in his opinion, the interests might conflict.

Before any consulting engineer takes over the work of another consulting engineer he should ask the client his reasons for desiring to change engineers and unless the consulting engineer is entirely satisfied that the client has good and sufficient reasons for making the change he should confer with the present incumbent before accepting the work.

Consultations should be encouraged in cases of doubt or unusual responsibility. The aim should be to give the client the advantage of collective skill. Discussions should be confidential. Consulting engineers should not say or do anything to impair confidence in the engineer in charge unless it is apparent that he is wholly incompetent or the interests of the profession so require.

Engineers acting as experts in legal and other cases, in making reports and testifying, should not depart from the true statement of results based on sound engineering

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principles. To base reports or testimony upon theories not so founded is unprofessional.

An engineer should make every effort to remedy dangerous defects in apparatus or structures or dangerous conditions of operation, and should immediately bring these to the attention of his client or employer. As failure of any engineering work reflects upon the whole profession, every engineer owes it to his professional associates as well as to himself that a reasonable degree of safety be provided in all work undertaken.

OWNERSHIP OF ENGINEERING RECORDS AND DATA

It is desirable that an engineer undertaking for others work in connection with which he may make improvements, inventions, plans, designs, or other records, should first enter into an agreement regarding their ownership.

If an engineer uses information which is not common knowledge or public property, but which he obtains from a client or employer, resulting in plans, designs, or other records, these should be regarded as the property of his client or employer.

If a consulting engineer uses only his own knowledge, or information which by prior publication, or otherwise, is public property and obtains no engineering data from a client or employer, except performance specifications or routine information; then in the absence of an agreement to the contrary, the results in the form of inventions, plans, designs, or other records should be regarded as the property of the engineer, and the client or employer should be entitled to their use only in the case for which the engineer was employed.

All work and results accomplished by an engineer in independent practice in the form of inventions, plans, designs, or other records, which are outside of the field of engineering for which a client or employer has retained him, should be regarded as the engineer's property unless there is an agreement to the contrary.

When an engineer or manufacturer builds apparatus from designs supplied to him by a customer, the designs remain the property of the customer and should not be duplicated by the engineer or manufacturer for others without express permission. When the engineer or manufacturer and a customer jointly work out designs and plans or develop inventions, a clear understanding should be reached before the beginning of the work regarding the respective rights or ownership in any inventions, designs, or matters of similar character, that may result.

Any engineering data or information which an engineer obtains from his client or employer, or which he creates as a result of such information, must be considered confidential by the engineer; and while he is justified in using such data or information in his own practice as forming part of his professional experience, its publication without express permission is improper.

Designs, data, records, and notes made by an employee and referring exclusively to his employer's work, should be regarded as his employer's property.

A customer, in buying apparatus, does not acquire any right in its design, but only the use of the apparatus purchased. A client does not acquire any right to the plans made by a consulting engineer except for the specific case for which they were made, unless there is an agreement to the contrary.

THE ENGINEER'S RELATIONS TO THE PUBLIC

The engineer should endeavor to assist the public to a fair and correct general understanding of engineering matters, to extend the general knowledge of engineering, and to discourage the appearance of untrue, unfair, or exaggerated statements on engineering subjects in the press or elsewhere, especially if these statements may lead to, or are made for the purpose of, inducing the public to participate in unworthy enterprises.

Technical discussions and criticisms of engineering subjects should not be conducted in the public press, but before engineering societies or in technical publications.

It is desirable that the first technical descriptions of inventions, or other engineering advances should not be made through the public press, but before engineering societies or through technical publications.

It is unprofessional to give an opinion on a subject without being fully informed as to all the facts relating thereto and as to the purposes for which the information is asked. The opinion should contain a full statement of the conditions under which it applies.

Engineers engaged in private practice should limit their advertising to professional cards and modest signs in conformity with the practice of other professions.

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THE ENGINEER'S RELATIONS TO THE ENGINEERING FRATERNITY

The engineer should take an interest in and assist his fellow engineers by exchange of general information and experience, by instruction and similar aid, through the engineering societies, the engineering schools, or other means. He should endeavor to protect all reputable engineers from misrepresentation.

The engineer should take care that credit for engineering work is attributed to those who, so far as his knowledge of the matter goes, are the real authors of such work.

Criticism of the work of one engineer by another should be broad and generous with the facts plainly stated. The success or failure of one member reflects credit or discredit on the whole profession.

The attitude of superiors toward subordinates should be that of helpfulness and encouragement. The attitude of subordinates to superiors should be one of loyalty and diligent support. The treatment of each by the other should be open and frank.

The attitude of an engineer toward contractors should be one of helpful co-operation. Tact and courtesy should be combined with firmness. An engineer should hold a judicial attitude toward both parties to a contract for whose execution he is responsible.

An engineer in responsible charge of work should not permit non-technical persons to over-rule his engineering judgment on purely engineering grounds.

An Experience With Water Ram*

ABOUT three years ago the Northeast Harbor Water Co. experienced difficulty with fluctuations of water pressure arising from the operation of a hydraulic elevator. The company served notice upon the proprietor of the building in which the elevator was installed to put in a tank to supply water through a 4-in. service pipe for the operation of the elevator instead of drawing water for that purpose directly from the 8-in. street main. The proprietor objected to installing tanks. The company notified him that his water supply would be shut off unless he complied with their requirements. At that point the proprietor brought suit in equity to enjoin the company from shutting off his water. The result of the case, which was tried in April 1910, may be summarized briefly as follows: The court decided that the use of water for a hydraulic elevator was a domestic use within the ordinary meaning of that term. On this ground it ruled that the company was obliged to furnish water for a hydraulic elevator, if the proprietor so desired. The court ruled, however, that the company was justified in asking the proprietor to install a tank of suitable capacity to relieve the street mains from the water-ram caused by operating the elevator by direct pressure from the mains. The court decided, further, that the requirement of the company was justified, since its order was given to protect its own property and to safeguard the interests of other water consumers on the same main pipe-line. The injunction was not granted and the company was left free to enforce its ruling unless the proprietor substantially conformed to the requirements it laid down.

Charles W. Sherman, principal assistant engineer with Metcalf & Eddy, of Boston, was called as an expect witness by the proprietor. The results of tests made by Mr. Sherman in preparation for his testimony, as well as the principal figures submitted by the water company, were given in Mr. Sherman's paper before the New England Water Works Association at the annual meeting of the association which was held in Boston on January 8, 1913. The information here given is taken from Mr. Sherman's paper.

The hotel was supplied by a 4-in. pipe, 300 or 400 ft. long, leading from an 8-in. main supply pipe at a distance of some 2 or 3 miles from the pond from which the supply is taken. The hydraulic elevator—the only one in town—is of an old type and has a total lift of about 32 ft. The travel of the plunger is about 4 ft., and its diameter is 22 in. It was found that the elevator valve was made to open or close a series of

*Abstract from *Engineering & Contracting*, January 29, 1913.

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holes, with the intention of making the opening or closing rather slow; and that it was necessary to overhaul 4½ ft. of valve rope to open or close the valve, or 9 ft. to reverse the elevator. The static pressure at the hotel was about 40 lb. per square inch, and a relief valve set at 45 lb. had been installed near the elevator.

Nobody seemed to know just how long it took the elevator to make a trip, but it was conceded that it could hardly have been less than 30 seconds. Assuming this to be correct, the 22-in. plunger traveled about 4 ft., and consequently the displacement was 79 gal., in 30 seconds, or the flow was 158 gal. per minute. This flow corresponded to a velocity of less than 3 ft. per second in the 4-in. pipe, which is certainly not an excessive velocity. If this could have been checked instantaneously the resulting water-ram would have been considerable, but it would obviously have required an appreciable time to overhaul 4½ ft. of valve rope to shut off the water.

The data available before the water company had presented its case were not sufficient to enable Mr. Sherman to make an estimate of the increased pressure which might have resulted from the operation of the elevator, to which he would care to testify. In order to get some information an experiment was made, through the courtesy of the superintendent of the water works at Ellsworth, Maine, where the court was in session. Here a place was found where there was a 4-in. pipe, some 400 ft. long, supplying a locomotive standpipe, where the normal pressure was about 68 lb. per square inch. This branch, like that at Northeast Harbor, was from an 8-in. main leading from the reservoir at a considerable distance. No method was discovered of drawing water, or of opening and closing the valve, at the same speed as with the elevator, so it was determined to make the test as severe as possible. The pressure gauge was attached to a house service pipe about 150 ft. from the locomotive standpipe, and the standpipe valve was opened wide, as rapidly as possible, left open until a condition of steady flow was obtained, and then closed as rapidly as possible. Mr. Sherman estimated the maximum velocity in the 4-in. pipe at not less than 10 ft. per second. The time of opening the 4-in. valve was 30 seconds, and the time of closing was 20 seconds. The pressure dropped almost immediately upon starting the valve from 68 to 28 lb. per square inch, or to 41% of the normal. At the instant of closing, the pressure gauge registered 134 lb. per square inch, or 202% of the normal.

Mr. Sherman considers that this maximum pressure is not great enough to be dangerous to any well constructed pipe system, although he believes that the sudden fluctuations would doubtless be annoying at times.

The officers of the water company presented gauge readings showing what the actual fluctuations had been in various parts of town. The significant figures, as taken down during the testimony, are as given in the table.

PRESSURES OBSERVED AT VARIOUS PLACES DURING OPERATION OF HYDRAULIC ELEVATOR.

Pounds per square inch.			Per cent of normal.	
Normal.	Highest.	Lowest.	Highest.	Lowest.
56	75	40	135	71
58	60	35	104	60
55	62	32	112	58
32	40	10	126	31
32	50	10	156	31
60	80	40	133	67
58	85	35	147	60
55	75	35	136	63
54	70	25	128	46
51	70	28	137	55
30	50	10	167	33
30	50	8	167	27
28	60	10	213	35

The figures given in the table show that in general the operation of the elevator caused a drop in pressure ranging from 40% to between 60 and 70% when the valve was opened, and an increase in pressure, or water-ram, amounting to from 30 to 50% of the normal pressure under ordinary circumstances, and sometimes running up to about 100% increase in pressure.

These results confirm in a general way the conclusions reached by Mr. Sherman from the experiment described above—that the pressure might drop about 60% below to a maximum of about 100% above normal at the moment of closing the valve. These fluctuations are sufficient to cause annoyance, but where the normal pressures are as low as in the cases cited, should not be dangerous to the pipes.

Mr. Sherman points out that none of these results can be applied to conditions differing

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materially from those here described, but they may serve to give some indication of the extent of the water-ram that may be experienced in a small water works system from the rapid closing of valves or fire hydrants.

Highway Improvements in Washington

THE fourth biennial report of the Highway Commission of Washington for the period ended September 30, 1912, shows a commendable record for progress in highway improvements. Through the courtesy of W. J. Roberts, Highway Commissioner, we are able to give the following excerpts from his report, that will be of special interest to engineers engaged in road building in the West.—EDITOR.

Cost Analysis of State Aid Road No. 99, Walla Walla County.—Total length of improvement, 2.08 miles; total cost of improvement, $26,691.61. Extent of improvement: bridging and culverts, one 30-ft. span plate girder; one 24-ft. span of reinforced concrete; one 12-ft. span skew reinforced concrete; two 4-ft. span skew reinforced concrete; 216 lineal feet iron culverts; total cost, $5272.34. Grading 13,590 cu. yd. earth, loose rock, hardpan excavation and riprap, $4900.80. Asphalt macadam, 16,309 sq. yd., $14,181.11. Engineering and incidentals, $2330.36; total cost, $26,691.61.

Asphalt macadam was laid to standard specifications, in brief as follows: Upon a prepared and thoroughly compacted subgrade, 6 in. of crushed rock was spread, rolled, and filled with screenings until tight and solid. Upon this base, 3 in. of crushed rock which had been mixed thoroughly with 90% asphalt road oil, proportion 18 gal. per cubic yard, was spread and rolled until compact. This course was then sprinkled with 90% asphalt oil, rolled, and excess oil taken up with rock screenings. Treatment as outlined above, cost including all materials and labor, $0.8990 per square yard. The oil cost the contractor 5½c. per gallon in tank cars on the work. Owing to unforeseen conditions, the last 600 ft. of this improvement was changed to spread oil macadam. Five inches of No. 1 rock was spread on the prepared subgrade and water bound with dust fracture of rock. Surface was then sprinkled with 90% asphalt oil, 1 gal. to the square yard, and oil taken up with screenings. The cost, including preparation of subgrade, was $0.5516 per square yard. The actual labor cost of putting on flush coat over 9174 lineal ft. of road, including furnishing of all labor and material except oil, was $83.41, or a unit cost of ½ cent per square yard.

The following statement gives the progress by counties:

Adams—4.4 miles oil macadam; cost, $34,285.

Asotin—Preliminary resolution; no work done.

Benton—5.6 miles crushed rock macadam; estimated cost, $16,042.

Chehalis—7.5 miles gravel road; cost, $29,976.

Chelan—3.5 miles macadam; estimate, $12,152.

Clallam—1.0 mile spread gravel, $2139; trestle containing 350 M ft. timber, $7277; total, $416.

Clarke—2.3 miles gravel macadam, $12,353.

Columbia—4.0 miles macadam; estimated cost, $17,397.

Cowlitz—Nothing done.

Douglas—11.0 miles, covered by resolution; $11,042 available.

Ferry—Nothing done.

Franklin—3.25 miles 'Dolarway'; estimated cost, $19,723.

Garfield—1.0 mile water-bound macadam, $12,128, includes reinforced concrete culverts and retaining wall.

Grant—4.0 miles gravel road; estimated cost, $14,748.

Island—Nothing done.

Jefferson—3.0 miles gravel road; estimated cost, $9410.

King—3.25 miles gravel road, $16,975; 7.72 miles 'Warrenite' crushed rock base, $123,560.68; 2.5 miles 'Warrenite,' on 4-in. concrete base, $26,203; 2.84 miles paving brick, on 5-in. concrete base with concrete curbs, $57,088.

Kitsap—1 mile gravel road; estimated cost, $4000.

Kittitas—1.7 miles 'Dolarway,' cost $23,907.

Klickitat—3.0 miles water-bound macadam;

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estimated cost, $8810 (does not include grading).

Lewis—2.25 miles concrete road; estimated cost, $37,595.

Lincoln—3.0 miles macadam; estimated cost, $18,250.

Mason—1.0 mile gravel road; estimated cost, $6251.

Okanogan—4.5 miles stone roads from natural 'shale'; estimated cost, $8438.

Pacific—1.3 miles water-bound macadam, $6845.

Pend Oreille—Nothing done.

Pierce—8.1 miles 'Granocrete'; estimated cost, $132,968.

San Juan—1.0 mile macadam, $16,275.

Skagit—4.0 miles macadam, $16,275.

Skamania—1.0 mile natural 'shale' rock, cost $2629.

Snohomish—10.0 miles gravel, $26,227.

Spokane—1.5 miles asphalt macadam, cost $18,430; 2.0 miles gravel, cost $11,978; 5.57 miles asphalt macadam, cost $42,632; 14.0 miles gravel, cost $38,930; 1.46 miles water-bound macadam, cost $9496.

Stevens—6.0 miles gravel, $10,382.

Thurston—4.5 miles gravel, $9266.

Wahkiakum—Nothing done.

Walla Walla—6.9 miles crushed gravel; estimated cost, $58,244.

Whatcom—2.63 miles gravel, $18,071.

Whitman—5.5 miles oil macadam, $45,056; 2.0 miles water-bound macadam, $9817.

Yakima—2.06 miles oil macadam, $5976; 2.0 miles oil macadam, $9507; 1.0 mile oil macadam, $5881; 1.5 miles oil macadam, $9390; 2.0 miles water-bound macadam, $7368.

Summary—Miles of permanent highway, 169; cost, $1,039,217; average cost per mile, $6149.

Earth Roads.—A system of graded earth roads, properly maintained by the use of the road-drag, would be very inexpensive and would greatly improve present road conditions. The roads kept up in this way would be in shape for the permanent surface when the funds became available. By a graded earth road, I mean one properly crowned, with not to exceed 1 in. of crown per foot, properly drained and with fixed grades.

I wish to emphasize the matter of drainage as being absolutely vital, not only to the success of a graded earth road, but to the very existence of any type of hard surface which may be placed upon the road in the future. It is not sufficient to give a road a good crown, and allow the water which runs to the side ditches to seek its own outlet. The side ditch grades must be carefully planned in advance of construction, taking advantage of all topographic features which will help to remove promptly all water from the vicinity of the roadway. This is especially important in the case of new cuts and fills through alluvial or loamy material. Water is the natural enemy of the average earth road; and a carefully planned drainage system must be the foundation of any successful maintenance scheme. The chief tasks of those who are charged with the upkeep of a newly graded highway, will be the systematic use of a drag to fill up the ruts and shape the road so that the surface water will run to the side ditches at once; and keeping these ditches and their outlets free from accumulating silt and other obstructions.

In case funds are not available for properly grading an old road, a great improvement can be made by building up a crown with the road grader and drag. On all trunk roads, the roadway should not be less than 24 ft. wide. On the branch roads the width could be reduced, but should never be less than 10 ft. When the roadway is less than 16 ft. wide, a turnout should be built every 500 ft. In all fills a berm should be left between toe of slope and side ditches or borrow pits to allow for future widening of road.

Gravel Roads.—In some of our counties where the amount in the permanent highway fund was not sufficient to warrant the construction of a more permanent surface, I have approved plans for the construction of gravel roads. In general, the roadway has been 24 ft. wide. In some cases the gravel has simply been spread on the roadway and in other cases a subgrade has been constructed and the gravel has been sprinkled and rolled. The graveled surface has varied in width from 12 to 30 ft., and in depth from 4 to 8 in., depending upon the amount of travel and the kind of material in the roadbed. In some of the larger counties where a new position was required over the trunk roads, I have approved plans calling for a gravel surface, as it would not have been feasible to construct a more permanent surface on new fills.

If proper attention is given to mainten-

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ance, using the roller in case of rolled gravel roads, and the drag in case of spread gravel roads, these improvements will last for several years and will make a good foundation for a more permanent surface. The cost of these roads varied from $1000 to $7000 per mile, depending upon amount of construction required, proximity of suitable gravel pits, width of gravel, depending upon the amount and class of travel, depth of gravel, depending upon the kind of material in the roadbed.

Macadam Roads.—These roads have been constructed in two ways: with two courses of rock and binder, and with one course of rock and binder. The latter method is preferable. The roadbed should be shaped to a true surface, conforming to the cross-section, and thoroughly rolled. If found necessary, the subgrade should be sprinkled before rolling. Crushed rock or gravel of a size that will pass through a 3-in. screen and be retained on a ¾-in. screen should be spread over the road to such a depth that it will be at least 6 in. thick after rolling. A small amount of sand, rock screenings, or clay will aid in the compacting of this course. After this course is thoroughly compacted, broken stone screenings that will pass through a ¾-in. screen and containing dust of fracture should be spread in a thin layer over the course of stone and rolled. This operation should be repeated until no more dry screenings can be rolled into the first course of stone, then more screenings should be applied, sprinkled, and rolled. This operation should be repeated until the voids in the course of stone are filled and the course of stone is just covered. The surface should then be rolled until hard and smooth. Screenings should be applied from piles at the side of the road only, and not dumped on the subgrade nor upon the layer or course of stone in advance of the final surfacing. The contractor should not permit any travel upon the layer of screenings before rolling. During the final rolling of macadam, the earth shoulders outside of the macadam should be thoroughly compacted by rolling and sprinkling.

Spread Oil Macadam.—Several experiments have been made with spread oil macadam. The method used in Adams county is to complete a water-bound macadam, then apply 80% asphaltic oil at the rate of ½ gal. per square yard of surface. Sufficient screenings are then spread over the surface and rolled so that after rolling no oil will be exposed nor are there patches of surplus screenings. In some instances our experience has shown that the best results are obtained when a second coat of oil and screenings is applied, the second coat assuring that the surface shall be completely sealed.

Asphalt Macadam.—This type of road consists of an application of crushed rock and 90% asphalt road oil mixed mechanically, on a crushed rock base laid on prepared subgrade. The mixing is done in a batch-mixer, suitably arranged to receive simultaneous charges of rock and oil, and the mass is turned until all fragments of rock become coated. In this process the rock must be dry and free from an excess of dust of fracture and the oil must be kept at a temperature of about 200°F. After the asphalt macadam has been thoroughly rolled and compacted on the road, it is treated with a flush coat of oil, using about two-thirds of a gallon to the square yard. The excess oil is then taken up with screenings, containing a large percentage of dust of fracture, the rolling and application of screenings continuing until the oil no longer 'sweats' to the surface. This form of surfacing has been successfully laid in Yakima and Walla Walla counties at a cost of 90c. per square yard. This figure includes preparation of subgrade, a 6-in. base of crushed rock spread and rolled according to specifications, a 3-in. course of mixed asphalt macadam, application of flush coat, and all incidental rolling, screenings, etc., required.

Concrete Roads.—Engineers are experimenting with concrete roadways. They are building them in both 1 and 2 courses, with and without a bituminous wearing surface. They are using various proportions in the mixture of the concrete. The one-course method is being used in Wayne county, Michigan. They are laying the concrete 7 in. thick with a mixture of 2-3-6 and are using reinforced expansion joints every 30 feet.

In this state, in Lincoln county, the County Commissioners are building a half mile of plain concrete roadway, under the permanent highway act. The first course is a 1-3½-7 mixture, 4 in. thick; the top course is a 2-3-6 mixture 1 to 1½ in. thick. This road is costing about 90c. per square yard. Lewis county is building 2.8 miles of plain

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concrete roadway under the permanent highway law and one mile from the county road and bridge fund. The first course is a 1-3-5 mixture, 4½ in. thick; the top course is a 1-1-1 mixture, 1½ in. thick, with expansion joints every 50 ft. Both asphalt and tarred paper were used in expansion joints. This road is costing on an average $1.30 per square yard.

Franklin county is building under the permanent highway law a concrete pavement with bituminous wearing surface. The concrete base is one course of a 1-5 (about 1-2-4) mixture, 5 in. thick; the top course is ⅓ gal. of asphalt oil per square yard with screenings to take up the oil, expansion joints every 50 ft. The concrete base is costing $1.08 and the top dressing $0.17 per square yard. Kittitas county is building under the same act a concrete pavement with 'Dolarway' top. The pavement is one course of a 1-2½-5 mixture, 5 in. thick, and the top course of 'Dolarway' mixture and screenings is ¼ in. thick. Expansion joints every 50 ft. This road is costing $1.125 per square yard. Pierce county, under this law, is building a two-course concrete roadway known as 'Granocrete.' The first course is a 1-3-6 mixture, 4½ in. thick, and the top course is a 1-1½ mixture—one part cement to 1½ part of stone chips, 1½ in. thick. Expansion joints are put in from 25 to 50 ft. apart. This road is costing $1.40 per square yard.

Warrenite Roads.—'Warrenite' is a bituminous mixture with the voids reduced to a minimum and is laid 2 in. thick on either a crushed rock or concrete base. This is a patented pavement and the patentees prefer to use the crushed rock base. On four roads in King county this pavement on a 6-in. crushed rock base has cost on an average $1.67 per square yard.

Brick Roads.—These roads are built with a concrete base, not less than 4 in. thick, a 2-in. cushion of sand, and a wearing surface of No. 2 paving brick. Concrete curbs are built on either side, monolithic with the base. I would recommend that the specifications published by the National Paving Brick Manufacturers' Association be followed in the construction of all brick roadways. The contract price for the road being built in King county is $2.13 per square yard of completed roadway.

Maintenance.—As soon as a 'permanent' road is constructed the work of maintenance should begin. The work to be done depends upon the character of the road surface. Earth roads shaped and crowned are best maintained in good order by the use of the split-log-drag, or some drag of equal merit. The drag can be used on gravel roads with equal success. Those countries of Europe having the best roads employ the patrol system. If our expensive roads, roads that have cost $5000 to $10,000 per mile, are to be kept in first-class condition they must have constant attention. New York's commissioner reports that 698 men patrolled and kept in good order 3151 miles, or about 4.5 miles per man, at a cost of $140 per mile per annum. Every railroad efficiently managed has its section crew constantly repairing the damage to track or roadbed caused by traffic or storm. I believe that 5% of all moneys hereafter appropriated for the construction of roads should be set aside and made available for maintenance.

A New Oil-Engined Ship*

AN oil-engined vessel, the *Fordonian*, has just been finished and has received her initial trials. The ship was built by the Clyde Shipbuilding & Engineering Co., Ltd., of Port Glasgow, Scotland, and is the first vessel built on the Clyde propelled by two-stroke Diesel oil-engines.

The ship is 250 ft. long, 42 ft. 6 in. beam, 16 ft. 10 in. molded depth to the main deck, and 26 ft. 6 in. to the awning deck. The *Fordonian* has a 2-ft. frame pitch, and a dead-weight cargo-carrying capacity of 3300 tons on 16 ft. 6 in. draught. The draught on service is restricted to 14 ft., and the dead-weight capacity is thus reduced to 2200 tons. She is built to Lloyd's highest class for the Canadian Interlake Line, Ltd., of Toronto, for grain-carrying on the Great Lakes of Canada. The vessel conforms to the standards of Canadian lake practice in that she has a steering-pole forward to make quite handy the control from the forward

*Abstract from the *Canadian Engineer*, January 23, 1913.

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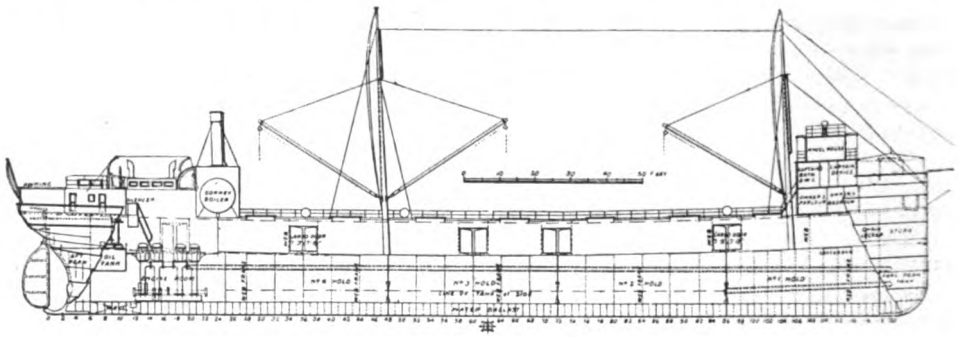
bridge, a large number of hatches, and inward opening cargo doors on the port and starboard sides to facilitate the rapid removal of cargo. The cofferdam at the forward end of the forehold is unusual in such vessels, and is intended to preserve the cargo from damage should the ship spring a leak as a result of coming in contact with any one of the many locks through which she passes in her regular trading. There are two independent controls from the bridge to the engine-room telegraph, and the steam steering-engine is operated by rods from the bridge.

As with sister ships, there are two masts with derricks on each, and the chart-house and navigating bridge are situated right

upon the high pressures of the Diesel cycle. These tend to give great rigidity; the engine ran entirely free from vibration. With this design of support the bed-plate must be strong to take the bending stresses between the column feet and the main bearings.

The arrangement of the engine into two units of two cylinders each permits of a two-piece crank-shaft in interchangeable halves, of the vertical spiral drive for the valve gear being taken from the centre of the engine, and also of the scavenging-pumps being driven from the two centre crossheads by links, as with the air-pump of steam-engines. The dimensions of the double-acting scavenging air-pumps are 27¼ in. diam.



DIESEL-ENGINED VESSEL, 'FORDONIAN.'

forward. The rudder is balanced and is of large area. In the trials the vessel turned almost in her own length, and when the helm was put hard over she almost came to a dead stop. The propeller is 11 ft. 9 in. diam. by 9-ft. pitch.

The main propelling engine is a 4-cylinder two-stroke cycle single-acting Carels type of Diesel oil-engine. The cylinder dimensions are 460 mm. (18.1 in.) diam. by 820 mm. (32.25 in.) stroke, and the engine runs normally at about 100 r.p.m. The bed-plate is of cast iron and is of the usual marine design, having a flat bottom and being supported in the centre as well as at the sides. This design contrasts with that evolved by many continental makers, who prefer the bed-plate supported at the sides only, with the cross-members of deep box section carrying the main bearings, which have forced lubrication. The columns of the engine are of the usual box section, bolted rigidly together at the top, and are very thick, to withstand the tension stresses consequent

with a 23½-in. stroke, and give thus a ratio of free air compressed for scavenging to combustion air taken into the main cylinders of 1.65, which is higher than the usual practice. The pressure of the scavenging air is 3 lb. per square inch.

The system of lubrication is interesting. For the main bearings solidified oil is used, for the crank-pin bearings the ordinary drip-feed suffices, and the bearing pressures for the main and crank bearings are respectively about 300 lb. and 650 lb. per square inch. For the lubrication of the crosshead bearing, a small lubricating-oil forcing pump is attached to each crosshead, and worked by the swing of each connecting rod, as shown. This system of lubrication permits of an open crank-case, and the bottom end bearings can always be easily felt by the engineer on watch. There are two guides for each, such being Messrs. Carels' practice for oil-engines. The piston is lubricated by four Mollerup lubricators, which force the oil between the piston and the cylinder; there

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are four inlets to the cylinder, and they are arranged to enter on the fore and aft and athwartship centre lines.

The control of the engine is by means of one wheel and two levers on the starting platform; one lever controls the compressed-air engine, which gives the cam-shaft its angular displacement by raising or lowering the vertical driving shaft, and also gives the maneuvering shaft its fore-and-aft movement. The other lever controls the fuel. The wheel operator by hand gives the maneuvering shaft its rotary motion. The cams upon the maneuvering shaft act upon the suction valves of the fuel-oil pump. Hand control is also provided by the handle on the column, which actuates a shaft running fore and aft on the engine, and so sets all the fuel-pump suction valves. Although compressed air is used for actuating the vertical shaft, causing the angular rotation of the cam-shaft and the rotation and displacement of the maneuvering shaft, hand-gear in emergency may be used.

Air storage for starting purposes is provided by four welded steel bottles, of 23⅝ in. diameter by 8 ft. long, and that for fuel injection by one bottle, 1 ft. diameter by 3 ft. long. The pressure of the fuel injection air and the starting air is 850 lb. per square inch, and for slow-running engines, such as this, this pressure is quite usual practice. The time taken by the auxiliary compressor to fill up the air-storage provided is about one hour. The remainder of the auxiliaries are normal steam practice, and call for no special mention.

The weight of the main engine alone is about 100 tons, and if the auxiliaries are included, all ready for work, 150 tons is the weight of machinery abroad. There is fuel storage in two oil-tanks placed on both sides of the oil-fired donkey boiler, and two ready-use tanks are placed aft of the engine-room, and are provided with steam-heating coils, while the oil is filtered, on its way to the fuel-pumps of the main engines, through 15-gal. filters in the engine-room. In all, 105 tons of oil fuel is carried, whereas with the sister steamship 250 tons of coal is required. The consumption per day for all purposes is 5 tons of oil fuel, against 14 tons of coal.

The fuel consumption of this engine is 0.47 lb. per brake horse-power hour, and this is good practice for two-stroke cycle engines with the scavenging pump and air-compressor driven off the main engine. The pressure of compression is 490 lb. per square inch. The indicated horse-power at 102 r.p.m. and 90 lb. per square inch is 970; 10 knots were achieved with the engines doing 128 r.p.m. The maximum revolutions were 140, the normal about 102, and the minimum 46. The results will undoubtedly be improved upon when the engines are finally tuned up, as prior to the trial trip they had only been run in dock trials for twelve hours in all. This is exactly the same treatment as is given to steam-engines.

The crank-shaft is in two interchangeable pieces, and there are two scavenging pumps of large capacity. The auxiliary air-compressor is of half the capacity of the main compressor, and since the vertical shaft-drive for the valve-gear is in the centre of the engine, should the compressor give out, one scavenging pump fail, or even the crank-shaft break, the main engine will still develop more than half its normal power. This type of engine seems very suited to the propulsion of cargo boats, and the saving in space consequent upon the adoption of the Diesel engine for this ship is five frame spaces, aggregating 10 ft., some 33% of the machinery space. The marine field is especially promising for the Diesel engine.

Standardization of the Myriawatt*

AT a joint meeting of a special committee of the American Society of Mechanical Engineers on 'myriawatt' with the standards committee of the American Institute of Electrical Engineers, on December 23, 1912, the following resolutions were adopted after a very full discussion:

Whereas, The 'myrowatt' or 'myriawatt' was suggested as a convenient unit of power only 2% larger than the most recently determined values of the 'boiler horse-power'; and,

Whereas, A paper setting forth the advantages of the use of the 'myriawatt' as a unit of power in dealing with the performance of steam boilers, steam-engines, gas-

*Abstract from *Journal* of the Am. Soc. M. E., February 1913.

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engines, steam and water turbines, was read before the annual convention of the American Institute of Electrical Engineers in Boston in June 1912, was discussed and was published in the *Proceedings* of the Institute; and,

Whereas, The American Society of Mechanical Engineers has appointed a special committee to confer with the Standards Committee of the American Institute of Electrical Engineers upon this unit, as presented in the said paper;

Be it Resolved, (1) That the two committees in joint session recommend in their respective societies the use of the 'myriawatt' as unit of thermal or mechanial power, as indicated in the above-mentioned paper; and (2) That the two committees also jointly recommend to their respective societies the exclusive use of the myriawatt in connection with boilers, producers, turbines, and engines, and discontinue the use of the term 'boiler horse-power.'

THE MYRIAWATT

By H. G. Stott and Haylett O'Neill

The object of this communication is to introduce a new unit of power, which, if adopted, will afford a basis of comparison of all converters of energy, thermal and mechanical, and also will be international in its character, as it is merely a new multiple of the watt.

In American and European practice, at the present time, there are in use many empirical units, the use of any one of which is restricted to a distinct territory. A few of the more important ones are: horse-power, boiler horse-power, kilowatt, cheval à vapeur, pferde-kraft, and poncelet. Obviously, an engineer in attempting to compare data from a foreign country, is compelled to face a confusion of terms, which usually can be made intelligible only by laborious calculations. Again, in the United States there are in vogue such units as boiler horse-power and horse-power, which, while similar in sound, have no logical connection; and one has yet to find where the 'horse' comes in. With the rapid development in electrical measuring instruments, and, until recently, a corresponding lack of development in steam-flow measuring instruments, the term kilowatt has become more and more used as the one unit of power output. The term became a necessity with the growing favor of steam turbines and all direct-connected units where it is impossible to measure accurately the mechanical and the electrical power separately.

To form a connection between the boiler or producer output, the engine and generator output, the term 'myriawatt,' derived from the Greek *myria*, meaning ten thousand, and the term watt, is proposed.

For the purpose of standardization, the British thermal unit 1/180 of the heat required to raise one pound of water from 32°F. to 212°F., and the equivalent evaporation from and at 212°F. (970.4 B.t.u.) is used (Marks and Davis).

From this, the following equivalents are obtained:

		B.t.u.
1 foot-pound	=	0.001286
1 kilogram-metre	=	0.009302
1 gram-calorie	=	0.0039683
		B.t.u. per hr.
1 horse-power	=	2,547
1 cheval à vapeur	=	2,512
1 pferde-kraft	=	2,512
1 poncelet	=	3,349
1 kilowatt	=	3,415
1 boiler horse-power	=	33,479
1 myriawatt	=	34,150

Reduction of the myriawatt to the above units:

1 mw. =

34,150	B.t.u. per hour
8,605,000	gram-calories per hour
26,552,000	foot-pounds per hour
3,670,900	kilogram-metres per hour
13.410	horse-power
13.597	cheval à vapeur
13.597	pferde-kraft
10.197	poncelets
10	kilowatts
1.020	boiler horse-power

Reduction of all the above units to myriawatts or myriawatt-hours:

1 B.t.u.	= 2.928	$\times 10^{-5}$ mw-hr.
1 gram-calorie	= 1.1621	$\times 10^{-7}$ mw-hr.
1 foot-pound	= 3.7662	$\times 10^{-8}$ mw-hr.
1 kilogram-metre	= 2.7238	$\times 10^{-7}$ mw-hr.
1 horse-power	= 7.457	$\times 10^{-2}$ mw.
1 cheval à vapeur	= 7.354	$\times 10^{-2}$ mw.
1 pferde-kraft	= 7.354	$\times 10^{-2}$ mw.
1 poncelet	= 9.807	$\times 10^{-2}$ mw.
1 kilowatt	= 1.0000	$\times 10^{-1}$ mw.
1 boiler hp.	= 9.804	$\times 10^{-4}$ mw.

The last two are practically the same, differing by only 2%. The usual practice is to rate water-tube boilers on the basis of one boiler horse-power per 10 sq. ft. of heating surface. With modern plants, notably those in marine service, operating from two to five times this rating, the ordinary method of determining nominal boiler capacity could be stretched 2% without materially affecting the present rating; that is, the boiler might be rated at 34,150 B.t.u. per hour for each 10 sq. ft. of heating surface, instead of at

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33,479 B.t.u. per hour for each 10 sq. ft. of heating surface. The myriawatt as a unit of boiler or producer output, and correspondingly a unit of input to all kinds of dynamical machinery, is fixed in value by the watt, and by its very sound gives a clue to its meaning.

To compare efficiencies of direct-connected units and eliminate the various factors of quality of steam, pressure, and vacuum, the term 'B.t.u. per kilowatt-hour' has been used. If we used the term myriawatt

$$\text{per cent overall efficiency} = \frac{10 \times \text{kilowatts output}}{\text{myriawatts input}}$$

Also, with the thermal efficiency of the engine known, the heating surface in the boiler-room is determined (assuming the 10 sq. ft. rule), thus: 2 kw. per myriawatt input to an engine is equivalent to 20% thermal efficiency of the engine and the heating surface in the boiler-room equals kilowatts engine output $\times$ 10/2. Obtaining an exact figure of the same with the boiler horse-power unit involves a tedious operation. The efficiency of internal-combustion engine-driven units of all cycles, such as Diesel, Brayton, Otto, etc., is determined by rating the heating value of the fuel in myriawatts; thus

$$\text{per cent efficiency} = 10 \times \frac{\text{kilowatts output}}{\text{myriawatts input}}$$

With hydraulic machinery, again rating the water-power input to the wheels in myriawatts:

$$\text{per cent efficiency} = 10 \times \frac{\text{kilowatts output}}{\text{myriawatts input}}$$

Thus, in the term myriawatt lies a simple, logical, and universal means of comparing outputs and inputs of all classes of energy converters, the meaning of which will be clear to all engineers wherever a piece of electrical machinery is to be found.

COMPARISONS IN EFFICIENCIES AND RATES OF OUTPUT WITH VARIOUS TYPES OF ENERGY CONVERTERS, IN TERMS OF THE MYRIAWATT

	Total draft head inches water gauge.	Boiler hp.	Myriawatts.
1—Boiler output: Nominal rating = 600 boiler hp	1.730	1375	1348

	Kw. output.	Lb. steam kw-hr.	B.t.u. kw-hr.	Kw. output Mw. input.	Thermal eff. overall, %.
2—5000-kw. engine	4,977	17.2	20,160	1.70	17
3—5500-kw. high-pressure turbine	8,183	16.39	18,450	1.85	18.5
4—15,000-kw. low-pressure turbine	11,240	13.19	15,660	2.18	21.8

	Brake hp.	Brake kw.	Kw. output Mw. input.	Conversion eff. overall, %.
5—56-in. low head water-turbine	283	211	8.41	84.1

6—Steam-plant efficiency:	
Lb. coal per kilowatt-hour	2
B.t.u. per pound of coal	14,250
B.t.u. per kilowatt-hour	28,500
Kilowatts per myriawatt input to boilers	1.2
Plant efficiency, per cent	12

	Kw. output.	Cu. ft. gas kw-hr.	B.t.u. kw-hr.	Kw. output Mw. input.	Thermal eff. overall, %.
7—Gas-power plant efficiency	5200	145	14,220	2.4	24

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Book Reviews

THE ECONOMICS OF RAILROAD CONSTRUCTION. By Walter Loring Webb. 332 pp., index. John Wiley & Sons, New York. For sale by the *Mining and Scientific Press*, San Francisco. Price $2.50.

This is the second edition of Mr. Webb's work, and has been revised throughout to conform to the new conditions brought about through the various rulings of the Interstate Commerce Commission since the first edition was published in 1906. The whole subject of railroad economics is so vast that it is not to be supposed that it can be completely covered by any one book. The author gives a bibliography in the introduction for those who desire to study the subject in greater detail. As the economic side is always the dominating one in any enterprise, an understanding of the principles and trend of economic progress in the exploitation and organization of large enterprises, and their relation to the people whom they serve is not only useful but necessary to the engineer of today. Mr. Webb's work is distinctly of value to engineers, and as he refrains from anything other than the recital of facts, statistical and otherwise, he avoids the pitfalls that await the author who takes sides in the never-ending controversy between the public utility corporations and the Government due to its efforts to control them, and at the same time preserve the benefits of their initiative, progress, and development. Much valuable data are given relating to the influence of engineering upon the economic side of construction and design, in fact, its effect upon the reader is to whet the appetite for more information along the same lines. The utility of Mr. Webb's work is unquestioned, particularly from the standpoint of the busy man who would be appalled at the number of huge volumes to which he would be directed should he ask for information on this subject at any library of consequence.

ENGINEERING OF SHOPS AND FACTORIES. By Harvey Grattan Tyrrell. P. 394. Index. McGraw-Hill Book Co., New York. For sale by *Mining and Scientific Press*, San Francisco. Price $4.

It has been recognized that the design of shops and factories is a problem for engineers rather than architects. Industrial engineering has become a specialized branch of the profession, as the commercial success of a manufacturing establishment is largely influenced by the design and arrangement of the factory. The author has had 20 years experience in this line of work and the readers will appreciate the thorough and practical manner with which the subject has been treated. The first chapter is decidedly helpful in the manner of its treatment of the preliminary financial arrangements between owners and the engineer. The importance of a thorough understanding in this direction is often lost sight of, and engineers will do well to take Mr. Tyrrell's remarks on this subject to heart. The arrangements of tools and appliances is treated at length, as well as the design of buildings, yards, and methods of handling raw and finished material. The economic side of the subject is duly emphasized, and includes a discussion of various types of building construction from the physical as well as the first-cost side.

Lighting, drainage, heating, water supply, and the sociological features are also subjects of chapters. The author is evidently free from bias in favor of any one material or method of construction, but discusses the characteristics of each from the standpoint of an engineer interested in the exposition of the entire subject. As a whole, Mr. Tyrell's work is a distinct addition to the literature within this field, and will be well received by all men interested in this phase of industrial engineering.

ELEMENTS OF HEAT-POWER ENGINEERING. By C. F. Hirshfeld and Wm. N. Barnard. 792 pp., index. John Wiley & Sons, New York. For sale by the *Mining and Scientific Press*, San Francisco. Price $5.

The authors have done excellent work in including under one cover not only the elementary thermodynamic theory of gases and their cycles, but also the consideration of the sources of heat, its utilization in the various types of prime movers and auxiliaries to which it is applicable, together with a discussion of the fundamental theory, the ideal and actual performance of the apparatus under working conditions. The text has been prepared primarily for advanced students in engineering who have had previous training in physics, chemistry, an-

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alytical and applied mechanics, and empirical machine design. The arrangement of the text is excellent, the various subdivisions under which the subject has been considered being treated in their logical sequence. No attempt has been made to expound new theories, the text being an exemplification of the fundamental laws and accepted theories pertaining to the subject under discussion and their application to the solution of the problems involved. The derivations as well as the formulae themselves are given in full; an essential to a thorough understanding of any subject which is frequently overlooked by many writers on scientific subjects. The steam engine and its performance is discussed at length, from the simplest forms of slide valve reciprocating engines to the highest types of steam turbines. Boilers, economizers, and other steam-utilization auxiliaries as well as the various kinds of fuel in use are treated at length. Consideration given to internal combustion engines is no less thorough. In this case, as in that of steam-engines, all types are considered from the single cylinder 4-cycle gasoline engine to the oil and suction gas-producer and Diesel types. Water purification, complete power plants, compressed air, and refrigeration are all subjects of chapters, in fact the impression given by this book as a whole is that a big subject has been treated comprehensively and at the same time is condensed within a comparatively small compass. Engineers engaged in the practice of this branch of the profession will appreciate its value as a book of reference, while students will find their studies greatly simplified through a careful perusal of its pages.

BOOK OF STANDARDS. 1913 Edition. P. 516. Index. National Tube Co., Pittsburg, Pennsylvania. Price $2.

The ordinary conception of the function of pipe is its use as a means for conveying fluids. It is a question, however, whether engineers appreciate how large a part pipe in its various forms is playing in the world of industry. The new edition of the Book of Standards, published by the National Tube Co., while giving due prominence to the ordinary use of pipe, shows that as a structural material for some forms of work it possesses advantages that are unequaled by any other structural shape. The first section of the book, after discussing the various processes of manufacture, contains tabulations of general dimensions, weights, and test pressures of the various types of commercial pipe and tubing. Types and characteristics of pipe joints are illustrated and described, and their application for various duties discussed. Standard specifications are also given at length and form the best means of informing oneself of the precision of modern pipe making methods. The space given to electric line poles is an indication of the universal application of pipe to this purpose since the publication of the previous edition. The section given to pump working-barrels, cylinders, and cylinder heads is especially interesting, as evidenced by the encroachment of wrought iron and steel pipe into a field in which cast iron has heretofore held undisputed sway. The fact that the joint between cylinder and head may in many cases be made seamless is not the least of the advantages offered by the substitution. The discussion and tabulated data given concerning the physical and thermal properties of pipe is exhaustive in its thoroughness and attention to detail. The mathematical formulæ, their derivation, and many curves comparing the results achieved by recognized authorities and investigators of the broad subject of the phenomena of fluid in pipes will be much appreciated by engineers who would ordinarily have to refer to many books to obtain the information given here under one cover. One of the most interesting sections of the book, especially to oilmen, is that on the collapse of tubes due to external pressure. At the instance of the National Tube Co., Reid T. Stewart, dean of the mechanical engineering department of the University of Pittsburgh, conducted an exhaustive series of experiments requiring the services of from one to six men for a period of four years. The results of Mr. Stewart's work are given in full and show conclusively the inapplicability of previously published formulæ to present-day conditions. In view of the fact that until the National Tube Co. took up this work the only basis for existing formulæ was the series of experiments conducted by Sir William Fairbairn in 1858, the importance of Mr. Stewart's investigations is at once apparent. Operating men in the oilfields will appreciate the advantage in using the data given as an aid in determining size of oil-well casing.

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Engineering Bonds

*Tax exempt in California.
†Legal investment for savings banks in California.
‡Available as security for deposit of state, county, and municipal funds and postal savings deposits.

The Los Angeles Railway Corporation has issued $3,000,000 of 5% 30-year bonds. The company has $20,000,000 common stock outstanding. The entire bonded indebtedness, exclusive of sinking funds, amounts to $19,565,000. The first and refunding 5s are part of an authorized issue of $20,000,000, of which $14,270,000 are now outstanding and $230,000 held in the sinking fund. No additional bonds can be issued under this mortgage except to retire at par the present underlying bonds.

The first and refunding mortgage 5s are secured by a direct first mortgage on more than 85 miles of track, a substantial part of the car and power equipment, and a large proportion of the corporation's real estate, and are also secured by a direct mortgage on all other property of the corporation subject only to the underlying bonds. The first and refunding 5s are also subject to a mortgage of the Los Angeles & Redondo Railway Co. on about 2½ miles of track.

Under the provisions of the mortgage the corporation is required to make sinking-fund payments amounting to $120,000 per year. This amount, together with interest on bonds kept alive in the sinking funds, will aggregate over $140,000 in 1913, available for retiring bonds of this and underlying issues at not over 105 and interest. The amount available in the sinking funds will increase annually as additional bonds are purchased, and it is estimated that it will be sufficient to retire over $7,000,000 bonds prior to maturity.

The company reports earnings for 1912 as follows, December being partly eliminated:

Gross earnings	$6,556,325
Operating expenses, including taxes and maintenance	4,574,334
Net earnings	$1,981,991
Annual bond interest charge	1,002,500
Balance	$ 979,491
Depreciation	500,000
Balance	$ 479,491

The Los Angeles Railway Corporation operates 371 miles of single track. The principal city lines are laid with seventy-two pound rail.

An issue of $600,000 in first and refunding 5% gold bonds dated June 1, 1911, and due June 1, 1941, has been placed upon the market by the Western States Gas & Electric Co. This company was incorporated in 1910 under the laws of the state of California and is a consolidation of the Humboldt Gas & Electric Co., the American River Electric Co., the Stockton Gas & Electric Corporation., and the Richmond Light & Power Co., and serves a population of approximately 75,000 in Stockton, Richmond, Eureka, Placerville, Florin, Elk Grove, Lodi, Galt, and other towns and suburbs in Humboldt, San Joaquin, and adjacent counties in California. The company manufactures and distributes about 15,400 hp., of which 8700 hp. is hydro-electric and 6700 hp. is generated by steam. It also manufactures and distributes gas in Stockton and Eureka. The bonds in question are secured by a first mortgage on the entire property of the company excepting that portion formerly owned by the American River Electric Co. These are secured by a mortgage on the latter company subject to $447,000 outstanding prior lien bonds. The statement of the earnings is as follows for the 12 months ended August 31, 1912:

Gross earnings	$942,038.54
Expenses and taxes	442,152.09
Net earnings	$519,886.45
Annual interest requirements on total funded debt, including present issue	$199,750.45

Sanderson & Porter, engineers, estimate the replacement value of the company's physical property, exclusive of franchises and going value, at not less than $4,825,000 on June 1, 1911. Since that date additions and improvements have been made costing in excess of $1,000,000. The company is controlled by the Standard Gas & Electric Co. through ownership of a majority of the stock of the West State Gas & Electric Co. of Delaware, which in turn owns the entire capital stock of the California company. The Standard Gas & Electric Co. is in turn controlled and operated by H. M. Byllesby & Co. of Chicago.

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Company Reports

The Coast Counties Gas & Electric Corporation, which owns the Coast Counties Light & Power Co., reports earnings for year ended December 31, 1912, as follows:

Gross earnings	$307,564.95
Operating expenses, maintenance, and taxes	158,908.08
Net earnings from operation	$148,656.87
Net profit received from Union Traction Co.	12,539.88
Net income available for bond interest	$161,196.75
Bond interest	72,560.00
Surplus	88,636.75

The report of the *Great Western Power Co.* for 1912 is as follows:

Gross earnings	$2,349,617
Operating expenses and taxes	1,002,960
Net earnings	$1,346,657
Fixed charges	891,080
Surplus	$ 455,576

The earnings statement of the *Holton Power Co.* for 1912 is as follows:

Total operating revenue	$176,303.76
Total operating expenses	92,103.42
Net operating revenue	$ 84,200.34
Deductions:	
Interest on bonds	$34,655.60
Other interest	12,757,05
Taxes	5,353.86
Total deductions	$ 52,766.51
Net income	$ 31,433.83

The Petaluma & Santa Rosa Railway reports for 1912 as follows:

Gross earnings	$308,164
Operating expenses	197,423
Net earnings	$110,741
Fixed charges	$ 59,645
Surplus	$ 51,095

Construction expenses in 1912 aggregated $59,929.13. The assets and liabilities of the company are placed at $2,021,127.07. Of the assets, $1,944,806.13 is assigned to plant account. The company is capitalized at $1,000,000 and has outstanding $694,000 of first-mortgage bonds and $217,000 of second-mortgage bonds, a total bonded indebtedness of $911,000.

The Pacific Light & Power Co. has issued a statement for the year 1912. The principal features of this statement are:

Assets		$7,671,746.11
Operating income		2,357,858.67
Expenses:		
Operating	$1,310,405.91	
Depreciation	544,601.19	
Taxes	98,620.33	
Miscellaneous	43,677.20	
		$1,997,304.63
Net		$ 360,554.04

The Southern California Edison Co. has filed a statement of its operations in the city of Los Angeles for the year 1912. The statement shows the following:

Operating income	$ 1,888,020
Operating expenses	1,421,446
Operating revenue	466,574
Value of property	11,895,959

San Joaquin Light & Power Corporation has reported earnings for December and for the year ended Dec. 31, 1912, as follows:

Month ending Dec. 31:	1912.
Gross income	$ 151,884.35
Operating expenses, maintenance, and taxes	57,245.91
Net income	$ 94,638.44
Interest charges and sinking fund	40,681.29
Balance	$ 53,957.15
12 months ended Dec. 31:	
Gross income	$1,387,459.13
Operating expenses, maintenance, and taxes	541,927.50
Net income	$ 845,531.63
Interest charges and sinking fund	450,319.00
Balance	$ 395,212.63

The San Joaquin Light & Power Co. has outstanding $6,500,000 6% cumulative preferred stock, the dividend requirements on which is $390,000. This the company earned and $5212 in addition. It is provided, how-

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ever, that until the surplus applicable to this purpose reaches one and a half times the requirements, or $585,000, cash dividends will be paid on only 28,000 shares, requiring $168,000, the balance of $222,000 being paid in additional preferred stock. Thus the cash requirements were earned considerably more than twice. The balance available for additions and betterments is $227,212.

The statement of earnings of the *Central California Gas Co.* for January 1913 is as follows:

Gross earnings	$4132.05
Operating expenses, taxes, and maintenance	2416.58
Net earnings	$1715.47

The Portland (Ore.) Railway, Light & Power Co., for December 1912 and the 12 months ended Dec. 31, 1912, reports earnings as follows:

December gross	$ 586,857
December net	308,174
December surplus	156,771
12 months gross	6,642,308
12 months net	3,313,397
12 months surplus	1,552,406

The Mexican Petroleum Co. now has under construction a fleet of six steamers, two tugs, two barges, and other floating equipment, with a total carrying capacity of 275,000 bbl. of oil, costing approximately $2,000,000, and intends to construct a topping plant for the production of naphtha and light gasoline distillate, costing approximately $300,000.

The two operating subsidiary companies have 18 wells, the total production of which is now and has been for the past two years approximately 285,000 bbl. per day. There are closed in 8 wells, whose last measured and present probable capacity is over 16,000 bbl. per day, making the total present capacity of completed oil wells about 44,500 bbl. per day, or about 50% in excess of the daily quantities now being delivered under existing contracts. Additional wells are now being drilled, and others will soon be commenced, which are expected to add largely to the present available production. The oldest well has been flowing for over eight years, the newest well for over two years.

The companies have in storage over 7,000,000 bbl. of oil, or a sufficient quantity to fill all present contracts for a period exceeding six months. The companies have contracts for the sale of petroleum to about twenty large purchasers, which amount to over 30,000 bbl. per day, and in the aggregate to over 60,000,000 bbl., of which 35,000,000 bbl. are for consumption in Mexico and over 25,000,000 bbl. for consumption in the United States. The average selling price of all the contracts is a little over 50c. per barrel.

Owing to lack of adequate ocean transportation facilities and to other temporary causes, deliveries during the past year have been less than the amounts called for by the contracts. For the ten months ended October 31, 1912, the total sales were approximately 7,000,000 bbl., or about 700,000 bbl. per month, as compared with an average of approximately 375,000 bbl. per month for the entire year 1911. The average deliveries for the ten months period of 1912 were about 200,000 bbl. per month short of the total called for by contracts, for the reason given above. In the month of November 1912 deliveries amounted to about 800,000 barrels.

The Long Beach Consolidated Gas Co., a corporation owned by the Southern California Edison Co., has asked the Railroad Commission for a certificate of public convenience and necessity for certain portions of the Bixby ranch. In connection with the application, the Long Beach Consolidated has filed a statement showing its financial condition, as follows:

Assets:	
Plant	$1,279,148.41
Bills receivable	18,097.02
Materials	15,030.30
Sundry	14,269.65
Total	$1,326,545.38
Liabilities:	
Common stock	$ 675,300.00
Preferred stock	85,000.00
Bonded indebtedness	489,000.00
Bills and accounts payable	107,963.63
Deposits	4,336.12
Accrued interest	2,720.84
Depreciation	13,397.72
Liability insurance	232.25
Surplus	8,194.82
Total	$1,326,545.38

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Engineers' Note Book

A Diagram for Area of Railway Culvert Openings*

By T. J. WRIGHT, Jr.

The diagram shown permits the graphical solution of the Wentworth formula for determining area of culvert opening required to carry run-off from any given area up to 1,000,000 acres. It has been found that this saves considerable time, and it may possibly be of interest to those who are working in districts where the formula is applicable.

The Wentworth formula† is in use by the Norfolk & Western Railway on that part of the line lying between the slopes of the Blue Ridge and the Ohio river, and owing to the fact that its use has been limited to this section (or others of similar topography) no rainfall or run-off factors have been necessary. It is discussed by Mr. Churchill, chief engineer of the N. &. W. railway, and by Mr. Wentworth, on pp. 35 and 143 of Bulletin 108, American Railway Engineering Association.

TABLE OF COMPARATIVE COMPUTATIONS OF CULVERT OPENINGS.

	Area drained.		Opening required, sq. ft.	
	Square miles.....	Acres	Wentworth formula	Assumed data ...
Fair Forest creek	.12	7,680	390	240
North Tiger river	.47	30,080	960	940
Middle Tiger river	.54	34,560	1050	1080
South Tiger river	.74	47,360	1300	1480
Enoree river	.59	37,760	1130	1180

I recently figured openings required for five streams at points between Greenville and Spartanburg, South Carolina. I used the Wentworth formula and checked the results by assuming a run-off of 100 cu. ft. per second per square mile, with a mean velocity of the stream of 5 ft. per second. These assumptions are warranted, I think, by the U. S. Geological Survey report on the Pacolet river flood of 1903. (Water Supply and Irrigation Paper No. 96.) The results were as given in the accompanying table. It has been my experience in general that the formula gives reliable results in the hilly country of the Virginias and in the Piedmont district of the Carolinas. In every case, however, consideration must be given to local conditions.

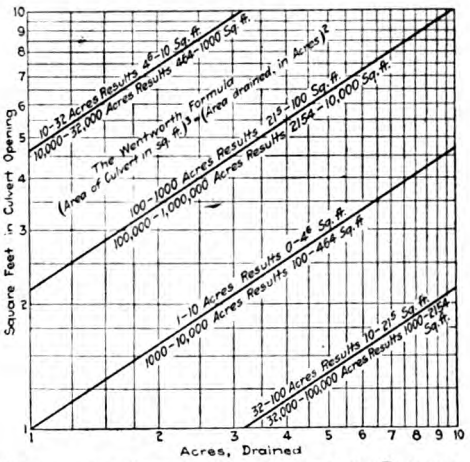
Square Feet in Culvert Opening
Acres, Drained
10-32 Acres Results 4.6-10 Sq. Ft.
10,000-32,000 Acres Results 464-1000 Sq. Ft.
The Wentworth Formula
(Area of Culvert in Sq. Ft.) = (Area drained, in Acres)^2/3
100-1000 Acres Results 21.5-100 Sq. Ft.
100,000-1,000,000 Acres Results 2154-10,000 Sq. Ft.
1-10 Acres Results 0-46 Sq. Ft.
1000-10,000 Acres Results 100-464 Sq. Ft.
32-100 Acres Results 10-21.5 Sq. Ft.
32,000-100,000 Acres Results 1000-2154 Sq. Ft.

DIAGRAM FOR DETERMINING THE AREA OF RAILWAY CULVERTS
(Based on the Wentworth Formula)

Example of Use of Diagram.—Find the area of culvert required to drain 440 acres. Enter the diagram at bottom at 4.4, and follow the vertical line to intersection with diagonal line marked 100-1000 acres (440 being between these limits). Thence follow the horizontal line to the border, which will be found to reach point 5.8. Since the result must lie between 21.5 and 100 sq. ft., the required area of culvert opening is 58 sq. ft. For 4400 acres, enter the diagram as before, but follow the vertical line to the diagonal line marked 1000-10,000 acres; thence follow the horizontal line, and the result is 269 square feet.

*Abstract from *Engineering News*, January 23, 1913.

†The Wentworth formula: $a = d^{2/3}$ where a is the sectional area of the waterway in square feet, and d is the drainage area in acres. This formula was derived in connection with work on the Norfolk & Western railway, and is especially fitted to the conditions in the southeastern states. In cases of less rainfall, or if the ground be quite flat, the author states that the two-thirds power of the drainage area is too great for the square feet of area needed in the waterway. In the observations of Mr. Wentworth, 60% of the resulting area may be taken as the lower limit.

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Hints on Practice

A BRIGHT SURFACE on galvanized wire may be obtained by excluding air from the zinc coating as the wire issues from the galvanizing bath. This is done by subjecting it, for a few inches of its length, to an inert gas, such as steam.

A SONOROUS ALUMINUM alloy for the production of house door bells may be mixed with the following: Chrome copper, 16 oz.; tin, 10 oz.; aluminum, 10 lb. To make chrome copper for this purpose, to every pound of melted copper add 1 oz. of powdered 60% ferrochrome.

PORTLAND CEMENT is made principally from the rock which is known to chemistry as carbonate of lime. The carbonic acid is driven off in the kiln. The chemical composition of the final product is about 63% lime, 20% silica, and the remainder alumina and iron, with a trace of magnesia; the latter not over 2 per cent.

Thirty years ago the value of natural gas produced in the United States was less than $500,000. There are now nearly 30,000 wells, producing annually more than 500,000,000,000 cu. ft. of gas, valued at nearly $75,000,000. Last year the output was 508,353,241,000 cu. ft., Pennsylvania being the greatest consumer with 154,475,376,000 cubic feet.

IT is stated that the first Diesel locomotive has been completed and is now undergoing preliminary workshop trials at the works of the builders, Gebrüder Sulzer, Winterthur, Switzerland. The locomotive has been built for the Prussian Hessian State Railway, the frame, wheels, axles, and general fittings having been made by the firm of A. Borsig, Berlin, while the engine is specially designed by the Swiss engineering concern mentioned above. The motor is a 4-cylinder one, developing 1000 hp. The total length of the locomotive between the buffers is 16.6 metres, and the weight, fully equipped, is 85,000 kilograms.

To resharpen old files, wash them in warm water to remove grease and dirt, then rinse in warm water and dry by heat. Put 1½ pints of warm water in a wooden vessel, put in the files, add 3 oz. of blue vitriol, finely powdered, and 3 oz. of borax. Mix well and turn the files so that every one may come in contact with the mixture. Add 10½ oz. sulphuric acid and ½ oz. of vinegar. Remove the files after a short time, dry, rub with olive oil, and wrap in porous paper. Coarse files should be kept in the mixture for a longer time than fine files.

ONE could easily write fifty-seven varieties of sermons about gaskets, poor packing, and the steam waste incident thereto, but this is not to be one of the regular fifty-seven varieties; it is to be a new and different one. There is many an instance when emergency, and a species of genius, have led a man, back in the woods, into taking his shirt-tail to make a gasket for a cylinder-head. And while this is often a poor and reckless makeshift, it is really better in effect than are some of the uses of thick gaskets where men think they have prepared and are doing the right thing. In the modern steam-engine the clearance space at the ends of the cylinder has been reduced to a point of small fractions, and even the added fraction of an unnecessarily thick gasket may cause useless waste of steam. Some of the old-style engines may be found yet in the rural districts that will show a clearance of an inch between the cylinder-head and the piston at the end of the stroke. And, strange to say, with this staring them in the face, it seems difficult for some to understand why a new engine of the same size will do more work and use less steam when the general construction is the same. In other words, there are some who do not seem to have realized that it takes steam to fill extra space in a cylinder, just the same as it takes steam to drive the engine—and it's the same kind of steam, too. To the class who are thus thick-headed belongs the engineer who puts gaskets an eighth of an inch thick under the cylinder-head simply because he has material of that kind in stock. He might better emulate the backwoodsman in emergencies and use a piece of his shirt-tail. Fortunately, there are not many of this class, even in the backwoods, but as long as the few remain it is in order to point out that all unnecessary space at the end of a steam cylinder calls for the expenditure of unnecessary steam power.—J. Crow Taylor in *The National Engineer*.

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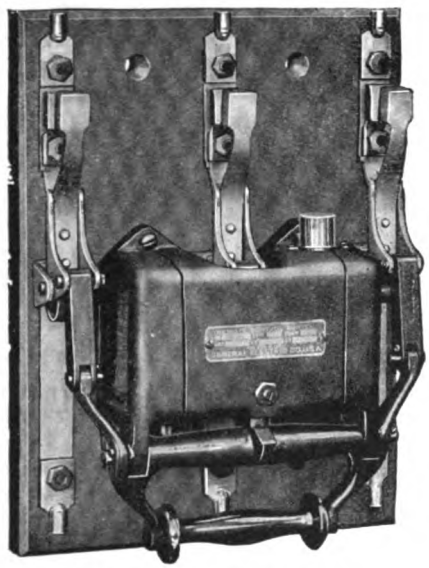
Industrial Progress

Distant Control of Small Capacity Power and Lighting Circuits

Electricity finds an interesting and useful application in the distant control of power and lighting circuits. A lighting company furnishing power on a flat rate basis for the operation of signs received numerous complaints when the electrical current was turned off by hand, the attendant, who could only be at one place at a time, could not switch the current off all signs simultaneously. The complaints dis-



DISTANT CONTROL SWITCH.

appeared when the current was cut off by remote-control switches, all tripped simultaneously by the throw of a switch at the station.

Such a distant-control switch has a wide field of application. The one shown in the illustration is substantially built and has few operating parts and so is suitable for installation at remote points where it may not receive a very great amount of attention.

The switch is operated by a double coil solenoid—one coil for closing and one for opening—controlled by a special, double push button switch, which is normally in the open position and remains closed only while held so by the operator. To open or close the switch, the corresponding button has to be pushed in. One of these switches is furnished with each remote-control switch and must always be used, as the solenoid coils are not designed to conduct their exciting current continuously. The cores of the operating solenoids are connected directly to the operating lever which in turn is connected to the poles of the switch through a toggle mechanism. When a coil of the solenoid is energized, its core moves the operating lever up or down, forcing the switch closed or open, whichever action corresponds to the coil that is energized. The switch can be operated by hand also, a handle being provided for this purpose and shown at the power part of the switch in the illustration.

This switch is a self contained unit with two sets of contacts, the main contacts being laminated copper brushes, while the auxiliary ones, on which the arc breaks on opening the circuit, are of carbon. The main contact brushes are so constructed that each lamination makes an end-on contact without any tendency to force the laminations apart. The laminations have a wiping effect in closing, thus keeping the contact surfaces bright, and ensuring good contact always. The carbon auxiliary contacts are made of blocks of selected carbon fastened on without screws or bolts, which ensures long life and satisfactory service.

The standard finish of all the live parts of the switch is polished copper, while that of the mechanism is marine (dead black).

The switch is made single, double, or triple pole, single throw for service on alternating and direct current circuits for potentials of 110, 125, 220, and 250 volts, and can be furnished up to 300 amperes capacity. Besides the service mentioned above it can be used to open or close power or lighting circuits of comparatively small capacity at some distant point. It is also used in office buildings, libraries, and public buildings, being installed in the supply circuits of cabinet panels and controlled from any desired point. The cabinet panels in the Prudential buildings, Newark, N. J., are thus equipped. Some other notable buildings provided with them are the Bankers' Trust building, the Mercantile Trust building, both of New York City and the Educational building, Albany, N. Y. The switch described above is manufactured by the General Electric Company of Schenectady, New York.

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Engineering News

Power, Gas, and Electricity

San Francisco.—Recent acts of the California Railroad Commission with regard to power and gas projects are as follows: Permission has been granted the Southern Counties Gas Co. to issue bonds to the amount of $10,000.——Permission has been granted the South Sierra Power Co. to increase its schedule of rates for electric-power service for pumping and for irrigation purposes in Riverside and San Bernardino counties, except within the limits of incorporated cities and towns within these counties.——A certificate of public convenience and necessity has been granted to the Los Angeles Gas & Electric Co. to construct and operate a pipe-line for the purpose of carrying natural gas along certain highways in Los Angeles county.——The application of the Mountain Power Co. to construct and operate an electric plant in Del Norte county has been dismissed without prejudice by request of the applicant.——The Imperial Valley Gas Co. has been authorized to proceed to issue bonds to the amount of $154,500.——A certificate of public convenience and necessity has been requested by the Beach Consolidated Gas Co., a subsidiary of the Southern California Edison Co., for certain portions of the Bixby ranch.——The application of the Arrowhead Reservoir & Power Co. to issue bonds in the sum of $4,000,000 has been denied without prejudice pending the settlement of certain litigation now pending in the Superior Court of San Bernardino county and in the United States Circuit Court at Los Angeles.——The application of the Tulare County Power Co. to issue $300,000 in bonds for the purpose of paying existing obligations and making extensions has been granted.——The Central California Gas Co. has been authorized to issue 6% preferred stock to the amount of $12,500 to cover organization and promotion expenses.——The Southern California Edison Co. has been granted authority to issue bonds in the sum of $2,500,000. The money is to be used for carrying out comprehensive plans for extensions; $1,000,000 is to be expended in completing units for the Long Beach steam plant. The balance will be spent for additions and betterments for the existing stations and improvement of the hydro-electric facilities, transmitting and distributing lines, and an addition to the general office building in Los Angeles.——Announcement has been made that the new hydro-electric power-plant of the Mt. Whitney Power & Electric Co. known as the Kaweah No. 3, has been practically completed. C. S. Conn, representing J. G. White Co., engineers, accompanied by John C. Hayes, has recently inspected the works. Everything will be in operation within 60 days.

Sacramento.—An appropriation of $300 has been made by the city to cover the expense of an expert inspection of all oil-burning and heating plants in the city.

Chico.—An electric generating plant operated by water power will be installed for the purpose of furnishing lights at Richardson's Springs and $10,000 is to be expended for this purpose. L. A. Richardson is general manager.

Greenville, Plumas County.—The Indian Valley Electric Light & Power Co. has investigated the feasibility of installing a hydro-electric power-plant to serve the Indian valley and North Plumas county districts. C. H. Miller is consulting engineer representing the bond buyers. O. C. Pratt is president of the company, with offices in the Crocker building, San Francisco.

San Bernardino.—At the hearing of the application of the Arrowhead company for permission to issue $4,000,000 in bonds it was alleged by Walter H. Brown that the dam at Little Bear valley is unsafe. F. E. Trask and F. C. Finkle, consulting engineers of Los Angeles, have denied the allegation of Mr. Brown.

Pendleton, Oregon.—The city has purchased a water-power site on the south fork of the Walla Walla river and a municipal power and lighting plant is contemplated.

Olympia, Washington.—The State Senate committee, in executive session, has voted in favor of the bill to oust the Northwestern Electric Co. from the White Salmon and Klickitat rivers, where power for the city of Portland is proposed to be generated. This bill, if enacted into law, will prohibit the use of water within the state of Washington for the generation of power to be used outside of the state except by such companies as are actually supplying interstate power on or before March 1, 1913.

Rochester, Nevada.—The Nenzel Electric Co. has been incorporated, with a capital stock of $250,000. Joseph F. Nenzel, J. T.

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Sullivan, J. F. Causten, and J. Burger are the incorporators. The principal place of business is designated as the Big Meadows hotel, Lovelock. It is proposed to put in a Diesel engine or steam-electric plant for supplying lights for the new city of Rochester. Units of 200 hp. each will be installed and ground is to be broken at once.

Spokane, Washington.—Details of the proposed electrification of the Chicago, Milwaukee & St. Paul railroad state that there will be 7 stationary power-plants, at least, generating electricity by water-power at Great Falls, Helena, Madison river, Big Hole, and Thompson falls, near the western border of Montana. All these will be connected in parallel, distributing their power to a single reservoir. Electricity will be conveyed to motors by means of a trolley system. Power will be purchased from the producing company, the railroad having nothing to do with construction and installation of power-plants. St. Paul probably will have 50 electric locomotives to begin the service, specially designed to meet the needs of the situation. These must pull a maximum freight tonnage of 2100 tons up a 1% grade. On heavy grades helpers will be added. The locomotives will be limited in design to a speed of 30 miles per hour up grade and 25 miles per hour down grade for passenger motors, and 15 miles per hour for freights.

Salt Lake City.—The Utah Power & Light Co. has completed the construction of a high-tension transmission line to the Scranton Smelting & Mining Co.'s plant at Scranton, Tooele county.

Streets and Roads

San Francisco.—Road construction to the county line has begun. A basalt-block pavement with an elastic foundation has been selected by the Board of Public Works for the improvement of San Bruno avenue for which $16,500 has been appropriated. As soon as further specifications have been prepared by the city engineer's office, the work will be continued south to Oakdale avenue. ——The Board of Supervisors has adopted a resolution to improve the following avenues from Mission road to Sloat boulevard: Silver and Cortland avenues from Mission road to San Bruno avenue; Fifteenth avenue south from San Bruno avenue to the county line; Corbett avenue from Seventeenth street to Sloat boulevard; View avenue from Diamond street to Corbett avenue; San Bruno avenue to Army street; from Railroad avenue to San Bruno avenue. ——The city engineer's office is preparing plans for the construction of Fifteenth street between Howard and Folsom streets.

Sausalito.—The town trustees have called for a bond election to provide $100,000 for paving Water street from the ferry building to the corporate limits of the town on the north.

Richmond.—Berg Bros. are reported to have let a contract for road and street work in the Nicholl tract amounting in all to $400,000. Concrete curbs and gutters will also be installed.

Sacramento.—Bids will be received up to 2 o'clock of February 28, at the office of the California Highway Commission in Sacramento, for portions of the state highway as follows: Mendocino county, between Ukiah and Forsythe creek, division 1, route 1, section C, about 7½ miles in length, to be built with gravel foundation and water-bound macadam surface; Los Angeles county, between Rancho el Encino and Calabasas, division 7, route 2, section B, about 10 miles in length, to be built of portland cement concrete and bituminized surface.——The board will let contract for a concrete road between Willitts and Ridgewood to Franklin & Baechtel for $29,987.——Bids were rejected for a section of the road in Butte county between Lindo channel near Chico and the north county line. The highest bid was $72,536 and the lowest $60,632, the estimate being $52,632.

Pendleton, Oregon.—Two more streets are to be paved as soon as the weather moderates. The streets are East Webb from Cottonwood to College, and College from Webb to Cort; approximately 3 miles of pavement will be laid in all.

Walla Walla, Washington.—The city commissioners have voted to abandon plans for paving Clinton and Whitman streets, and petitions will be circulated among property-owners of the district bound by Clinton, Boyer, Isaacs, and Madison streets, asking that the whole district be paved at the same time.

Davenport, Washington.—A good roads association was organized on February 8. The officers elected were: A. F. Kramer, of Almira, president; H. G. Burns, of Reardan, vice-president; G. G. Harvey, of Davenport, secretary-treasurer; George Witt of Harring-

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ton, F. W. Anderson of Davenport, D. F. McKay of Creston, O. F. Minch of Odessa, A. L. Smailey of Sprague, Godfrey Thompson of Wilbur, and J. G. Wolfe of Almira, trustees.

Dayton, Washington.—Steps are to be taken by the county commissioners to improve a section of the highway extending from the western limit of Main street for 3 miles, and a petition has been received by the commissioners asking for the improvement of the road leading from the Star bridge a distance of 1½ miles.

Railways

San Francisco.—The following statement of the valuation of 9 railroads in California was filed with the Railroad Commission by R. A. Thompson, chief engineer:

Road.	Original Cost.	Repro. Cost.	Present Value.
Amador Central.	.....	$372,325	$317,334
Iron Mt.	.....	301,022	227,803
Lake Tahoe Ry..	630,793	461,898	323,216
Pajaro Val. Ry..	560,236	747,295	540,782
Porterville N. E.	503,310	479,198	470,290
Sac. Val. Est....	549,007	392,382	349,669
Santa Maria Va.	234,966	232,150	216,509
Tonopah & T....	2,599,661	2,474,235	2,008,289
Yreka Ry.	.....	133,340	90,432

The Vallejo & Northern railroad has applied for a permit to cross the Southern Pacific at Suisun at the grade of its tracks. ——The California Railroad Commission has granted the application of the San Francisco Oakland Terminal Railways for a certificate of public convenience and necessity to exercise franchise rights to operate a street railroad along Standard avenue and on a private right-of-way in the city of Richmond.——The plans of the Southern Pacific Co. for a new depot to be erected at University avenue and 3rd street, Berkeley, have been approved by the Railroad Commission.——The Mill Valley & Mt. Tamalpais Scenic Railway Co. is to be re-incorporated with a capital stock of $500,000. This is an increase of $300,000, which is to provide funds for extensions and improvements.——The Vallejo & Northern Railroad Co. has applied to the Railroad Commission for permission to sell its property to the Northern Electric Railroad Co. The consideration is placed at $1,000,000 of Northern Railroad Co. bonds and $2,000,000 of Northern Electric 5% preferred stock. The acquisition of the Vallejo & Northern road gives the Northern Electric a direct line to San Francisco from Sacramento as well as terminal facilities at Vallejo.——The Fresno, Hanford & Summit Lake Interurban railroad has applied to the Railroad Commission for permission to issue $1,250,000 in bonds to provide funds for the construction of an electric railroad running from Fresno easterly to the town of Centerville, southeasterly to the town of Kingsburg. The new line will be 40 miles long. It is stated that the rights of way have been obtained, the roadbed practically completed, and that the necessary franchises have been obtained. The Sacramento Valley Electric Railroad Co. expects to begin construction work on August 1 and trains are expected to be in operation into San Francisco over the Oakland & Antioch system within the year following. The project contemplates construction of an electric line from Red Bluff to connect with the Oakland & Antioch several miles west of Sacramento.——The Railroad Commission has granted the application of the Southern Pacific company to increase its charge for switching freight in carloads from transfer tracks of the City Belt railroad in San Francisco to industry tracks and private sidings within the company's switching limits from $2.50 per car to 25c. per ton of 2000 lb., with a minimum charge of $5 per car.

San Jose.—It has been announced that construction work for the San Jose Terminal railroad between the city and the newly acquired port in the South bay will begin within 60 days. The grading has been practically completed for 10 miles of the right of way. The road will be operated in conjunction with a line of barges to San Francisco.

Colusa.—Amended articles of incorporation filed by the Northern Electric railroad announce that the company will construct a railroad from Woodland to Colusa, thence to Hamilton City, a distance of 108 miles.

Los Angeles.—The Santa Fé railroad has commenced construction work on a branch line from Oceanside through the San Luis Rey valley.——The Santa Fé company has authorized the expenditure of $200,000 for betterments on the direct line to Los Angeles. A list of the contemplated improvements includes the following: a new wheel shop and tracks at San Bernardino will cost

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$28,000. The installing of an automatic block system between Summit and Keenbrook will cost $20,000. Added trackage at National City is estimated at $11,100. Replacing curve-worn 85-lb. steel with 90-lb. rail in the first and third districts will cost $1500. New bridge near Bakersfield will cost $6700; improved water facilities at Richmond, $11,000; pavement and drainage at Hartford, $1890; 6 four-room section houses on the Albuquerque division will cost $10,044; automatic signals between Crookton and Ashfork will cost $25,000; building a second main track through the yards at Needles, California, will cost $89,000; and bridge building on that division will add $2533 more. Other expenditures are composed of a vast number of small betterments along the main line.

North Yakima, Washington.—Grading on the 6-mile line of the Yakima Valley Transportation Co. to Selah has been completed by Tribble & Bowen of Spokane. The cost is in excess of $100,000.

Spokane, Washington.—An appropriation of $4,000,000 has been made by the Northern Pacific railroad for construction of the Ellensburg cut-off.

Salt Lake City.—The concrete work on the bridge across the river at Provo for the Salt Lake & Utah Railroad Co. is making satisfactory progress. Contracts for bridge and trestle work will soon be let, including a trestle 500 ft. long and 40 ft. high near Provo, numerous culverts and crossings along the right-of-way. S. S. Arenz is the engineer in charge of construction.

Butte, Montana.—It has been stated that the Soo Line will expend $25,000,000 on the construction of 725 miles of new railroad across the state of Montana.

Pittsburg, Pennsylvania.—A new electro-pneumatic brake, the invention of Walter V. Turner, chief engineer of the Westinghouse Air Brake Co., is being tested out on the Pennsylvania railroad.

Irrigation and Water Supply

San Francisco.—The annual statement of the Marin Water & Power Co. for 1912 is as follows:

Operating revenue	$121,766.97
Operating expenses	55,587.07
Net operating revenue	66,179.90
Other income	1,520.00
Total net	67,699.90
Less interest	33,076.13
Net	34,623.77
Less dividends	18,000.00
Surplus	16,623.77

The annual statement of the San Jose Water Co. for 1912 is as follows:

Operating income	$186,018.17
Operating expenses	103,858.12
Operating revenue	82,160.05
Other receipts	815.00
Net revenue	82,975.05

The Railroad Commission has granted permission to the Palmdale Water Co. to purchase the entire system of the South Antelope Valley Irrigation Co. in Antelope valley, Los Angeles county, for $75,000. A decision has also been rendered authorizing the Domestic Water Co. of Santa Maria to purchase the Santa Maria Water Works and to issue stock to the amount of $25,000 and bonds to the amount of $85,000.——The project of utilization of the water of Lake Tahoe for power and irrigation purposes has resulted in much opposition from property-owners and the state authorities. M. M. O'Shaughnessy and A. W. Maltby are acting on behalf of the Secretary of the Interior. The Reclamation Service engineers claim that government control of the lake would benefit property and that the lake level would be more constant under government control and improve sanitary conditions. The property-owners, represented by Edwin Duryea, Jr., consulting engineer, contend that a greater fluctuation than 4 ft. in the water-level would cause injuries to property around the lake amounting to several million dollars. The engineers of the U. S. Reclamation Service join with the Truckee General Electric Co. in an effort to appropriate part of the water for the operation of power-plants and the irrigation of 206,000 acres of land known as the Truckee-Carson project in Nevada.

Sacramento.—W. E. Gerber, president of the California National Bank in this city, states that the Sutter Basin reclamation project has been completely financed and that work will be inaugurated within 60 days. George Randle is chief engineer of the project and the Armour interests in Chicago are said to be financial backers.——The Yuba Farm Lands Investment Co. has purchased the Ayer ranch, north of Marysville, including 1300 acres. This company now holds 15,000 acres of land in Yuba county. Water

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rights have been secured on the Yuba river, and the tract is to be subdivided and placed under irrigation. The men interested are J. M. Henderson, Jr., Edward W. Yardley, and D. W. Carmichael of Sacramento, E. Richardson and T. M. Baer of Visalia, and others. M. M. O'Shaughnessy, city engineer of San Francisco, is consulting engineer, and T. B. Harrington of Sacramento is engineer in charge of construction.——The city engineer has been instructed to prepare an estimate of the cost of installing additional pumps in the city water works to double its present capacity.

Placerville.—An irrigation project involving the utilizing of the watershed of the Cosumnes river, covering 110 square miles, is in process of formation. T. G. Patton of Placerville, O. Scribner of San Francisco, and C. B. Bills of Sacramento are promoting the project.——The Hayward-Lane & Hobart Estate Co. is preparing for the construction of a dam at Becker's ford, two miles south of Somerset, for utilization of 500,000 miner's inches of water to be diverted from the middle fork of the Cosumnes river.

Grass Valley.—The Nevada Water Consumers' Association is contemplating the irrigation of 5000 acres of land. A. L. Wisker and Fred M. Miller, county surveyor, are in charge of operations. They are negotiating with the Pacific Gas & Electric Co. for water.

Marysville.—One thousand acres of land in township 16 has been sold to the Cordua Land Co., of which Newton Cleaveland, of San Francisco, is the head. The land will be subdivided and placed under irrigation.

Live Oak, Sutter County.—A bond election is to be held for the purpose of providing $79,000 for the creation of a drainage district.

Montague, Siskiyou County.—The Montague Water Co., formed to develop a water-supply for Montague, has organized by electing the following officers and directors: Charles H. Simon, president; Charles Schook, Sr., vice-president; T. J. Nolton, secretary; and H. H. Hudson, treasurer; and August Janson.

Redding, Shasta County.—A company is to be incorporated for the purpose of pumping water for irrigation of 1200 acres of alfalfa land. Those interested are Wesley Harris, Charles Davie, Mrs. A. Thierkoff, George Thompson, John Dinsmore, Charles Hampton, Mrs. M. Deakin, W. J. Logan, Clyde Brown, Ernest Rolinson, Dennis Desmond, and B. Schaub.

El Centro, Cal.—The receiver for the California Development Co. has received permission from the courts to enter into a contract to supply water to the Southside Water Co. of Imperial Valley.

Spokane, Wash.—The city council has awarded a contract for 2000 Trident water meters at a total price of $17,860.

Ellensburg, Wash.—Farmers in the vicinity of the Cascade canal have voted to bond their land for $600,000 for the formation of an irrigation district.

North Yakima, Washington.—Land-owners in the vicinity of Priest rapids are preparing to install pumping plants and carry on other development work for the irrigation of 100,000 acres of land in the vicinity of Columbia. Milton E. Dam, secretary of the Priest Rapids Land Owners' Association, has the matter in hand.——The Pacific Power & Light Co. has made a formal offer to the city to sell its water plant for $500,000 in cash or bonds. The property constitutes the city distribution system, 10 miles of wood-stave pipe-line, and a perpetual water right to 10 sec.ft. of water from the Nachez river. The company will also undertake to convey the water to the headgate of the wood pipe from a point 10 miles up the river.

Olympia, Washington.—A bill has been introduced in the State Senate by Arthur McGuire and H. J. Fisk providing for a $40,000,000 state bond issue for the reclamation of arid lands in Grant, Adams, Chelan, and Douglas counties, including in all 435,000 acres. The project has been worked out by the Quincy Valley Water Users' Association with the assistance of Henry Lands, state geologist, and Joseph Jacobs, engineer.

Salt Lake City, Utah.—The Buckhorn Land Co. has filed an application with Caleb Tanner, state engineer, for permission to divert water from the Bull Hollow and price river for purposes of providing 8000 acre-feet of water for the irrigation of 11,000 acres of land on Buckhorn flat in Emery county. It is proposed to conserve the flood-waters of the Cedar mountains with a large reservoir. Lloyd Sigler is general manager of the Buckhorn company, which consists of a number of Salt Lake City capitalists. A channel ½ mile long, 44 ft. wide, and 6 ft. deep will be dug at a grade of 5 ft. per mile. A dam will be built and various other improvements made.

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Miscellaneous Engineering Construction

San Francisco.—Word has been received that Rudolph Hering, who has made a report on the method to be used for the repair of Nashville masonry reservoir, has advised that further leaks into the shale foundations of the reservoir, 150 ft. of the wall of which slid out on November 4, may be prevented and the east basin made safe at a cost of $93,115. In addition to replacing the broken wall, it is recommended that the east basin be given a 'cement-gun' coat of cement mortar and the floors be waterproofed by asphalt felt protected by concrete, and that a waterproofed wedge be built at the junction of the wall and bottom, and drain placed beneath this wedge. Mr. Hering reported that the density of the 'gun' cement is great, that it penetrates into all open crevices and covers every fine crack, and an average thickness of about 1 inch is more than enough to make a wall entirely water-tight.——Contract for a pier over 1000 ft. long, being part of the San Francisco harbor improvement project, has been let to the Healy-Tibbetts Construction Co. for the sum of $436,400. This will be pier No. 39, to be constructed north from the foot of Lombard street along the seawall. No wharves have existed here before. It will be 1008 ft. long and 140 ft. wide.

Berkeley, California.—The city council has awarded a contract for the municipal incinerator to the Refuse Disposal Co. for the sum of $61,250. The contract calls for the construction to commence not later than March 9 and completion with 180 days.

Martinez.—The contract for construction of a new municipal wharf has been awarded by the city trustees to the Mercer Fraser Co. for $26,445. Work is to be commenced at once.——The city trustees are contemplating the erection of a drawbridge over Alhambra creek.

Sacramento.—A special bond election has been called by the city commissioners for April 5 for the purpose of providing funds for the construction of a sewer system in the annexed territory.——The city engineer has been instructed to make plans and specifications for the construction of a water-distributing system, together with an estimate of cost, and have it ready to submit to the commission by March 10.

Alameda.—The City Electric Commission has awarded a contract to Robert Dalziel Co. for the construction of a city wharf and pipe-line for the municipal light plant at the south end of Park street. The price is $16,229.

Princeton, Colusa County.—The city council is contemplating the construction of a new bridge at a cost of $100,000. J. W. Kearth is county surveyor.

Los Angeles.—The American-Hawaiian Steamship Co. has applied for a wharf franchise for 930 ft. of city land for the purpose of constructing thereon a wharf 1000 ft. long.——The city engineer has drawn up plans for an assessment district to provide for a storm drain sewer in Canal street, Wilmington, from Tenth street to the waterfront.——The Board of Public Works, on the advice of the harbor engineer, has rejected all bids for bridging and filling a portion of Wilmington street south to Front street.——The bid of 23¾c. per cubic yard was stated to be too high; 1,000,000 cu. yd. of material was to have been removed.——Holt & Jeffrey, the successful bidders for the construction of the Arroya de la Brea storm drain have declined to sign the contract, on the ground that defects have been found in the proceedings which will invalidate the assessment. Their bid aggregated $538,844.34. The matter has been referred to the city attorney for a report.

Phoenix, Arizona.—A bill providing for an appropriation of $25,000 for a bridge over the Colorado river at Yuma, contingent upon a like sum being provided by the state of California and by the Federal Government, has been passed.

North Yakima, Washington.—The City Commission has called for a special election for March 18 to vote $260,000 in bonds for the construction of a new sewer system and a disposal plant. N. A. Gilman is city engineer.

Salt Lake City, Utah.—P. J. Moran, contractor and builder of this city, is planning to erect a steam-heating plant at an estimated cost of $1,000,000. Franchises are to be applied for at once.

Lewiston, Idaho.—The Security Bridge Co. has commenced work on the bridge which is to span the Clearwater river. The pouring of concrete for the piers has commenced. The contract price for the entire job is $45,000.

Riverside, Cal.—Burns & McDonnell, consulting engineers of Kansas City, Missouri,

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have reported upon the various improvement projects now under way for the city of Riverside. Bonds were voted on January 14 amounting in all to $1,160,000, covering the purchase of three privately owned waterworks plants that had been serving the city. The Riverside Water Co.'s domestic system was appraised at $575,000, the Riverside Artesian Domestic System at $195,000, and the Keyes Domestic Water System at $15,000. The estimate for extensions, improvements, and consolidation of the three plants amounted to $375,500. The improvements consist of three reservoirs, new main supply line (30-in. diam.) to the city, additional artesian wells, and a pumping station consolidating the three plants. The water company has agreed to sell at the appraised valuation, and the works will be taken over by the municipality within a short time. The future improvements are planned to take care of a population of 30,000. The valuation and appraisement work, as well as plans and supervision, will be carried on under Burns & McDonnell, engineers, who will maintain an office at Riverside for handling this and other work in the western states. An efficiency report for municipal lighting improvements for Riverside has also been completed. Riverside has owned its municipal lighting plant for about sixteen years, and it has always been considered one of the most efficient of municipal plants, but through a desire to raise the efficiency, a thorough investigation of the plant and report on future improvements, changes in operation, and other features that would tend to lessen the cost of producing electricity and raise the efficiency was made. This work involved a study of the rates, cost of operation, maintenance, future improvements and power, and in this connection several alternate projects have been considered for reducing the cost of producing electricity. The hydro-electric plant, securing power from the San Jacinto mountains, at an estimated cost of $429,112; cost per kilowatt, $285. A new steam-plant was considered as an alternate project at an estimated cost of $100,351; cost per kilowatt, $50. An oil-engine plant was considered at an estimated cost of $120,000; cost per kilowatt, $100. A combination plant consisting of oil-engines, steam-turbines, and steam-engines, with a total kilowatt capacity of 2000, is recommended, at a total cost of $112,300.

Petroleum

California oil dividends for January were as follows:

*Amalgamated	$1.000	$ 50,000.00
*American Pet. pfd.	0.005	8,255.50
*American Pet. common	0.001⅛	39,607.00
Caribou	0.01	8,070.30
Central	0.0075	7,500.00
Claremont	0.01	4,500.00
Columbia Con.	0.015	45,000.00
Continental	0.015	4,200.56
Euclid	0.005	17,000.00
Fullerton	0.05	30,000.00
Home (Coalinga)	0.01	10,000.00
Monte Cristo	0.02½	12,500.00
Mount Diablo	0.075	7,500.00
New Pennsylvania	0.005	5,000.00
Olinda Land	0.075	15,000.00
Paraffine	0.01	3,000.00
†Peerless	0.25	25,000.00
Pinal	0.01	15,000.00
S. F. & McKittrick	0.10	5,000.00
‡Sauer Dough	0.015	2,992.50
Section 25	0.50	20,000.00
State Consolidated	0.01	5,000.00
*Traders	0.60	9,000.00
*Union	0.60	184,753.60
*Union Provident	0.60	91,403.02
*United Petroleum	0.60	48,450.60
*West Coast pfd.	1.000	10,408.00
*Western Union	0.50	5,000.00
Total		$679,149.08

*Par value $100.
†Par value $10.
‡Par value 50 cents.
'Unmarked, par value $1.

Production statistics for California fields for January were as follows:

	Net Jan.	Daily Av.
San Joaquin Valley:		
Coalinga	1,455,820	46,968.39
Kern River	825,389	26,625.45
Maricopa	430,447	13,885.39
Midway	2,251,296	72,662.44
McKitt.-Belridge	548,897	14,480.55
Lost Hills	159,022	5,139.74
Total	5,670,871	
Coast-South:		
*Santa Maria	378,200	12,200.00
Olinda-Brea-Puente	532,304	17,171.09
Salt Lake	190,181	6,134.87
Whittier	60,324	1,945.93
Coyotes-La Habra	193,997	6,258.29
Ventura County	68,294	2,203.00

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Newhall	9,353	301.71
Los Angeles City	31,842	1,027.17
Summerland	4,350	140.32
Total	1,468,845	
Grand net total state	7,139,716	230,315.35
Shipments	6,994,840	225,640.00
Losses	89,108	2,874.45
Total outgo	7,083,948	228,514.45
Surplus	55,768	1,798.97

*Santa Maria, Lompoc, Cat Canyon.

Field fuel amounted to 427,073 bbl., 175,000 of which was in Kern River.

Exports for January were as follows:

	Gallons.	Value.
Crude	777,210	$ 10,454
Illuminating	8,810,401	422,650
Gasoline, etc.	213,001	32,260
Lubricating	98,352	22,246
Fuel oil	19,618,976	328,725
Asphaltum:	Tons.	Value.
Crude	27	$ 890
Manufacturing	244	3127

Field development and conditions for January were:

		Wells Drill.		Completions.		Producers.	
	New Rigs.	Active.	Idle.	No.	Output.	Active.	Idle.
Coalinga	2	62	58	5	850	854	241
Kern	5	7	4	3	30	1690	190
Maricopa	3	34	57	4	3,400	283	119
Midway	12	105	87	27	3,415	685	250
McKittrick	6	14	41	7	1,490	304	29
Lost Hills	3	18	34	3	390	56	1
Santa Maria	..	18	40	..	.....	268	20
Fullerton	..	26	4	..	.....	329	18
Salt Lake	1	11	1	4	200	289	13
Whittier	..	8	3	..	.....	141	13
Coyote	1	27	2	3	1,630	15	1
Ventura	4	29	27	4	225	315	25
Newhall	..	2	3	..	.....	79	4
Los Angeles	..	...	..	..	.....	412	...
Summerland	..	...	..	..	.....	125	25
Total	37	361	361	60	11,630	5845	949

Wells abandoned: Coalinga, 1; Midway, 4; McKittrick, 1; Salt Lake, 7; total, 13.

*Santa Maria	284,283	423,474	707,757
†Olinda	33,313	177,985	211,298
Salt Lake	97,953	34,507	132,460
Whittier	40,145	.....	40,145
Coyotes-La H	33,421	.....	33,421
Ventura County	16,787	71,535	88,322
Newhall	2,412	.....	2,412
‡Los Angeles	15,000	247,131	262,131
Outside of fields		8,826,347	8,826,347
Totals	2,248,187	45,508,330	47,756,517

*Santa Maria, Lompoc, Cat Canyon.

†Olinda, Brea Canyon, Puente.

‡Los Angeles City and District.

A summary of dividends paid by California oil companies during 1912 shows a total of nearly $50,000,000. The following is a list of companies that have paid $1,000,000 or more:

Union Oil	$12,139,459.55
Imperial	4,060,000.00
Amalgamated	2,350,000.00
American Petroleum	2,422,573.25
Associated	1,548,368.54
Monte Cristo	1,415,000.00

Stocks on hand at the end of January were as follows:

	Field stocks.	Pipe-line.	Total.
Coalinga	463,933	2,487,306	2,951,239
Kern River	423,884	29,814,402	30,238,286
Maricopa	289,806	429,437	719,243
Midway	435,600	1,834,127	2,269,727
McK.-Belridge	96,950	861,643	958,593
Lost Hills	14,700	300,436	315,136

Caribou	1,350,000.00
Standard Oil of California	1,125,000.00
Reed Crude	1,124,000.00
Brea Canyon Oil Co.	1,122,000.00
Central	1,082,000.00
Pinal	1,000,000.00
Peerless	1,000,000.00
Total	$31,638,401.34

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The following have paid less than $1,000,000 and more than $500,000:

Sterling	$ 778,250.00
Fullerton	771,600.00
Thirty-three	670,000.00
Bakersfield-Fresno	600,000.00
Columbia	599,623.14
Palmer	575,780.42
Claremont	574,771.99
Sauer Dough	565,780.42
Western Union	545,943.50
Home (Coalinga)	524,000.00
San Francisco and McKittrick	515,000.00
Total	$6,720,749.47

The following have paid less than $500,000 and more than $250,000:

Section 25	$ 470,000.00
California Oilfields, Ltd.	460,000.00
Brookshire	442,500.00
East Puente	380,000.00
Record	342,000.00
Producers	292,000.00
United	270,068.14
Bay City	255,000.00
Buick	256,000.00
Total	$3,157,568.14

Martinez.—Work on the new refinery for the Associated Oil Co. is making rapid progress. Application has been made to the Contra Costa County Supervisors for a franchise to construct and maintain a wharf to extend nearly 2000 ft. from the shore. The 42,000,000-gal. oil reservoir is completed and excavations for the foundations for the engine and pumps are ready.

El Segundo.—The Standard Oil Co. has commenced the erection of five 1000-bbl. stills in addition to the original 15 that have been in operation since the refinery commenced operation. The asphalt plant is expected to start operations about March 1.

Los Angeles.—Suits have been filed by the Federal Government against 25 defendants in the Kern county oilfields, including the Consolidated Midway Oil Co., the National Pacific Oil Co., and the Standard Oil Co. The suit alleges illegal entries on oil lands in Kern county involving title to 160 acres of land valued at $500,000.

Santa Maria.—The Union Oil Co. will commence the installation of four regular units of its gasoline-from-natural-gas plant and expects to have them in operation within six months. Each unit will have a capacity of 2,000,000 cu. ft. of natural gas per day and 1000 gal. per 1,000,000 ft. is expected to be the average extraction, giving a total output of 8000 gal. of gasoline per day. It is expected that four additional units will be added as soon as the first installation is completed. The order for the high-pressure two-stage compressors and engines has been placed with the Snow Pump Co. of Buffalo, New York, through its San Francisco office. A pipe-line of 2-in. diam. will be laid from the plant to the topping establishment at Port Harford, where the gasoline will be blended with the lower-grade distillate.

Obituary

LEE M. HYDE, one of the best known civil engineers in California, died on February 6 of blood poisoning following a surgical operation. Mr. Hyde's illness and subsequent death was due to exposure during a trip of inspection through the Santa Barbara water supply tunnel.

FRANK SOULÉ, professor emeritus of civil engineering at the University of California, died at his home in Berkeley on February 14 following a stroke of apoplexy. He was 78 years of age and had been a member of the faculty of the University for over forty years. He was a graduate of the West Point Military Academy and was for a time instructor in ordnance and gunnery at West Point. He joined the faculty of the University of California in 1870 as assistant professor of mathematics. In 1872 he was made professor of civil engineering and ultimately became dean of that department. He retired from active work about seven years ago and since that time has given his attention to writing and trips of observation.

Society Meetings

AT the annual meeting of the Washington Association of Engineers held at Seattle February 7, J. Thomas Dovey was elected president, Clarence White vice-president, and Sterling Hill secretary and treasurer.

THE UTAH SOCIETY OF ENGINEERS has arranged to use the headquarters of the Salt Lake Stock & Mining Exchange as a place for holding its regular monthly meetings. Papers read at the meeting of February 21 included one on 'Reclamation and Drainage

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of Water and Alkali Lands,' by R. A. Hart; 'Pumping for Irrigation,' by C. H. Mills; and 'The Strawberry Project,' by J. T. Lytle.

THE regular February meeting of the Cleveland Engineering Society was held on February 11. A paper was presented by C. D. Smith, engineer for the Bureau of Mines at Pittsburg, Pennsylvania, on 'Gas Producers and Producer Gas.'

THE ENGINEERS' CLUB of San Francisco, at a meeting held at the Palace hotel on February 25, passed a resolution authorizing the president to appoint a committee to consummate a lease and make other arrangements for the occupancy of permanent quarters for the club in the Balboa Bdg., corner of Second and Market streets, San Francisco.

Commercial Paragraphs

W. RAY THOMPSON, county engineer of Pierce county, Washington, has advocated the use of the split-log drag for the maintenance of earth roads within his jurisdiction.

CUMMINGS & KIEHL, Seattle and Vancouver, have the contract for furnishing and laying 5800 ft. of riveted steel pipe, ranging from 48 to 84 in., for the Lake Buntzen power plant of the Vancouver Power Co., replacing wood stave pipe.

W. W. LUCIUS, 315 Lewis Bdg., Portland, is preparing plans for a 150-ft. reinforced concrete bridge, with a 34-ft. roadway, for Lewis county, Washington. He is also preparing plans for the structural steel work for an $80,000 reinforced concrete theatre building to be erected at Portland.

KIBBE-WELTON CO., of Portland, has just completed two large paving contracts on Portland Heights; a concrete pavement and an elevated reinforced concrete sidewalk were installed. Concrete piling was used to provide foundations, and is a new method of construction for hillside work and is proving superior to the old gravity or retaining wall type.

What is said to be the largest order for electrical apparatus ever placed in the history of the industry has been received by the GENERAL ELECTRIC CO. for the city of Melbourne, Australia. Melbourne will spend $12,000,000 in the electrification of all its steam roads, $4,000,000 of which will be paid for equipment ordered from the GENERAL ELECTRIC COMPANY.

Catalogues Received

KOEHRING MACHINE CO., Milwaukee, Wisconsin. 'The Mixer' for January 1913. General information concerning the use and application of this well known type of concrete mixer.

BEAUDRY & CO., INC., 141 Milk St., Boston, Massachusetts. Catalogue illustrating and describing the Beaudry power hammers, which are made in a variety of sizes suitable for all sizes of forge shops.

THE BRISTOL CO., Waterbury, Connecticut. Bulletin 138, showing time recorder for recording time of mechanical movements, machine operation, valve reversals, etc. Bulletin 139, mechanical time recorder for continuously recording time and extent of mechanical movements. Catalogue No. 1200, class 11, recording thermometers for temperatures between 90 and 500° Fahrenheit.

GENERAL ELECTRIC CO., Schenectady, New York. New publications. Bulletin No. A4027, in colors, devoted to the subject of Edison Mazda sign lamps, is an exceptionally attractive publication from both a pictorial and engineering standpoint. Much valuable data concerning lighting problems is given. Bulletin A4085, battery-charging motor-generator sets for railway signaling, contains information and dimension sheets that will be especially interesting to railroad men. Bulletin A4083 describes U. S.-13 roller-bearing trolley bases. Bulletin A4086 describes type M. R. circuit breakers for railway service. Bulletin A4081 describes reversing motors for planers, slotters, etc. Much valuable data is given showing the advantage of direct over belt drive; auxiliary appliances are also described. Bulletin A4070 shows type R form C2 electrically operated remote control switch; a more extended description of this interesting apparatus is given in the Industrial Progress section of this issue. Bulletin 4850C, Edison Mazda lamps for standard lighting service. Bulletin A4080, electricity in excavation and construction work; this bulletin contains information of special interest to engineers on the Pacific coast by reason of the abundant and cheap electric power available in the interior. Electricity is in many cases superseding steam in construction work. Bulletin A4073, electric equipment in bakeries, showing the application of electricity and electrical apparatus in providing the staff of life.

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Personal

AMOS SLATER has returned to Seattle from Victoria.

F. J. WALSH, of Portland, is making an extended Eastern trip.

C. W. WILLETTE, of Seattle, was a recent visitor in San Francisco.

M. J. FALKENBURG, of Seattle, is making an extended Eastern trip.

V. H. REINEKING, of Portland, has been in Seattle on professional business.

PAUL P. WHITHAM has been appointed chief engineer of the port of Seattle.

CHARLES KIRBY FOX has returned to New York from an inspection trip to Panama.

JOHN H. BURGARD has been appointed a member of the Portland Dock Commission.

A. L. VALENTINE has been reappointed superintendent of public utilities at Seattle.

H. K. OWENS, of Seattle, is making a trip of inspection to Panama by way of New Orleans and Cuba.

ROBERT HOWES, consulting engineer of Seattle, is making an inspection trip through British Columbia.

GEORGE NELSON, of Los Angeles, is consulting engineer for the Redondo Beach Good Roads Association.

JAMES A. KELLY, of Seattle, designed and supervised the construction of the coal-washing plant at Issaquah, Washington.

E. K. BARNUM, formerly resident engineer on the Nisqually power plant at Tacoma, has been made superintendent of operations.

W. D. MARKS, of New York, is making an examination to report on the physical valuation of the Spokane Gas & Fuel Company.

J. L. STANNARD and A. L. RICHARDSON have been at Pendleton acting as expert witnesses in a suit involving a water-power plant.

S. L. Van Ornum has resigned his position as city engineer of Pasadena to engage in consulting practice, with offices in San Francisco.

O. H. WAGNER has been appointed superintendent of the Westside power plant of the California-Oregon Power Co., at Klamath Falls, Oregon.

M. J. KERWIN, of Coalinga, has been appointed oil-well commissioner of the Coalinga oilfields by the Board of Supervisors of Fresno county.

C. E. GRUNSKY has testified as an expert witness on behalf of the Yolo Water & Power Co. in the suit involving various questions dealing with its water-supply.

ANDREW M. MORTENSEN, of Los Angeles, has been appointed manager of the Bakersfield Iron Works, a subsidiary of the Associated Oil Company.

JAMES WILSON, of Seattle, division engineer for the Chicago, Milwaukee & St. Paul railroad, will take charge of the engineering work in the Spokane district.

JOHN H. LEWIS, state engineer of Oregon, recently addressed the Oregon Society of Engineers on the proposed power plant at Celilo Falls on the Columbia river.

ALFRED D. FRINK, formerly on the engineering staff of the Los Angeles Aqueduct, has been appointed chief of the department of roads for the Pacific Home Builders.

L. F. HARZA, of Portland, has reported to the state engineer on the feasibility of developing water power at Five Mile Rapids, above The Dalles on the Columbia river.

J. J. WITT has been appointed general superintendent of all of the Standard Oil Company's pipe-lines in the San Joaquin valley and will make his headquarters at Bakersfield.

THOMAS HAWTHORNE will engage in consulting engineering practice, specializing upon irrigation problems, and has opened offices in the U. S. National Bank Bdg., Portland.

A. G. HOIT, division engineer for the Chicago, Milwaukee & St. Paul Railroad Co. in Spokane, has been appointed assistant chief engineer for the company, with headquarters in Chicago.

W. W. BRIGGS has resigned his position as assistant general manager of sales for the Westinghouse Electric & Mfg. Co. to become assistant to the president of the Great Western Power Company.

E. M. ANDERSON has given expert testimony dealing with geological problems involved in the suit pending between the Federal Government and the Southern Pacific company in the Elk Hills oil lands case.

ALFRED STILL, formerly chief electrical engineer of the mines department of the Algona Steel Corporation of Sault Ste. Marie, Ontario, Canada, has taken charge of the course in electrical design at the School of Electrical Engineering, Purdue University, Lafayette, Indiana. Mr. Still has recently returned from an extensive tour of inspection and study of hydro-electric power on the Pacific coast and Colorado.

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